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LITERATURES OF STRESS: THERMODYNAMIC PHYSICS AND THE POETRY AND PROSE OF GERARD MANLEY HOPKINS

by

THOMAS MAPES

Under the Direction of Paul Schmidt, PhD

ABSTRACT

This dissertation examines two of the various literatures of energy in Victorian Britain: the scientific literature of the North British school of energy physics, and the poetic and prose literature of Gerard Manley Hopkins. As an interdisciplinary effort, it is intended for several audiences. For readers interested in science history, it offers a history of two terms – stress and strain – central to modern physics. As well, in discussing the ideas of various scientific authors (primarily William John Macquorn Rankine, William Thomson, P.G. Tait, and James Clerk Maxwell), it indicates several contributions these figures made to larger culture.

For readers of Hopkins' poems and prose, this dissertation corresponds with a recent trend in criticism in its estimation of Hopkins as a scientifically informed writer, at least in his years post-Stonyhurst. Accordingly, this dissertation presents readings of Hopkins' poetry and prose in light of developments in Victorian energy physics. Three claims span the chapters pertaining to Hopkins' oeuvre: First, that Hopkins' distinctive terminology of stress and instress expresses the energetic relations between objects. Second, that Hopkins' metaphors and analogies are unusual in that they often signify literal relationships between things compared, particularly when metaphysical forms of stress or instress are likened to physical forms of energy. And third, that in Hopkins' writings the natural world and the supernatural order of creation are contiguous, and that energy suffuses both.

INDEX WORDS: Nineteenth century literature, Victorian literature, Gerard Manley Hopkins, Thermodynamic, Interdisciplinary, Physics

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by

THOMAS MAPES

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of

Doctor of Philosophy

in the College of Arts and Sciences

Georgia State University

2015

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LITERATURES OF STRESS: THERMODYNAMIC PHYSICS AND THE POETRY AND PROSE OF GERARD MANLEY HOPKINS

by

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May 2015

DEDICATION

For Lisa. And for Carrie, my co-co Christa.

ACKNOWLEDGEMENTS

I would like to thank my Georgia State professors for their knowledgeable and patient instruction over the too-many years that I have been a graduate student here. First and foremost, special thanks to Dr. Paul Schmidt, who introduced me to the poetry of Gerard Manley Hopkins, and whose support made it possible for me to continue as a student and to complete this dissertation. Dr. Schmidt is my model of what a professor should be. His classes never fail to instruct and delight, and his counsel and friendship have encouraged so many of his students, including me. When Newman devised his idea of a university, his idea of a professor must have been inspired by someone very similar to Dr. Schmidt.

I also wish to thank Dr. Leeanne Richardson. As her student, I have been consistently impressed with her energy, and the care and pride that she takes in her scholarship, teaching, and personal relationships. I particularly thank Dr. Richardson for her attentiveness to her students' work, and for her consistently insightful and conscientious written responses to papers and presentations. It is always a pleasure to read her feedback, and her responses to this dissertation have sharpened the present instance of it and have given me ideas for the future. Likewise, as her subeditor at the *South Atlantic Review,* I appreciated the freedom she allowed me in my work balanced by her interest for my work.

Special thanks to Dr. Randy Malamud, who graciously stepped in as my third reader halfway through this dissertation. He promptly read the chapters I had written previously, and thereafter returned feedback chapter by chapter as I completed them. His diligence and supportive criticism greatly aided me through the middle and final stages of the project.

My thanks to the many others among the GSU faculty. Along with Dr. Schmidt's and Dr. Richardson's stimulating classes, Dr. Michael Galchinsky's teaching enticed me to specialize in

Victorian literature. As well, Dr. Galchinsky introduced me to the structuralist criticism central to chapter four, and helped me to narrow and define the focus of this dissertation. He also provided insightful feedback for chapter two. Dr. Wayne Erickson helped me to improve my writing, and I take his enthusiasm for students, poetry, and poetic form as a model for my own pedagogy. Likewise, I am mindful of Dr. Stephen Dobranski's superb Milton classes, and his careful responses to my written work.

To my family, my gratitude for your love, patience, and – not least – your endurance. Particular thanks to Lisa for her longsuffering forbearance as I laboriously typed for too many hours too late at night. I owe her many hours of watching Carrie. Few spouses would be as patient as you have been, and for that especially, and for everything else you are to me, my endless thanks.

To my mom and dad, many thanks for the confident support, the Sunday meals, the lodging on Sunday nights, the good conversation, the Scrabble competitions, the space and time for family fun. Above all, thank you for your consistency and faithfulness, and for establishing a loving home where your children and grandchildren can grow.

And finally, to Carrie … daddy's finished! Let's go play.

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1 INTRODUCTION

The steam engine and the industrial revolution made energy a matter of public concern and private interest. What was it? Did it actually exist, or did the terms "energy" and "force" merely describe relationships between objects? Could it be lost? How could heat be converted into other forms of energy – work, electricity, light, sound? And perhaps most importantly for a society so conscious of the price of manufactured goods: How could energy be conserved? How could the most work be derived from the least fuel? In terms of human awareness at least, energies proliferated as the nineteenth century progressed. Steam engines turned heat into mechanical work, trains changed it to momentum, thermal couplings to electricity, and dynamos and arc lamps into light. Everywhere, clanking, chugging, puffing, whirring, shrieking machines turned heat to sound. Light, heat, magnetism, electricity, work: energy was ubiquitous in Victorian industry.

Technology and science followed industrial needs in perfecting the steam engine, an effort that necessarily involved physicists and engineers in the study of energy efficiency to maximize production while economizing fuel. Such investigations, applied to the world at large, led to a new paradigm of the sun and stars as inconceivably powerful engines, yet fueled by finite energy and ultimately capable of limited production. According to the new science of thermodynamics, though energy may not be destroyed, it perpetually escapes from areas of high concentration in stars and suns to areas of low concentration in surrounding space. At some point, as entropy increases or the energy difference between stars and space approaches equilibrium, the stars and sun will go out and the cosmic system will no longer sustain life. The laws of the new science, then, pointed to a time of future apocalypse or "heat death" during which the magnificent engines of the cosmos would run short of fuel and cease production -- of heat, light, and even life itself.

Scientists and engineers were not alone in thinking about energy and its manifestations. Michel Serres has called the painter J.W.M. Turner "the first true genius of thermodynamics" in that his vividly colored sunsets and novel treatment of light articulated a new and industrial sensibility of "matter transformed by fire," or of the world reconceived in terms of the energy that suffuses and animates it (57). Likewise, Barri Gold describes how Tennyson's "pre-scient" grasp of thermodynamic physics prepared culture to embrace the emerging science and even aided "the shaping of what [Victorians came] to know as scientific fact" (40). As these scholars show, energy was not the proper domain of scientists and engineers alone, but of painters and poets as well.

This dissertation will examine two of the various literatures of energy in Victorian Britain: the scientific literature of the North British school of energy physics, and the poetic and prose literature of Gerard Manley Hopkins. As an interdisciplinary effort, it is intended for several audiences. For readers interested in science history, it offers a history of two terms – stress and strain – central to modern physics. Likewise, in discussing the ideas of several scientific authors (primarily William John Macquorn Rankine, William Thomson, Peter Guthrie Tait, and James Clerk Maxwell), it indicates some of the contributions that these ideas made to larger culture.

For readers of Hopkins' poems and prose, this dissertation corresponds with a recent trend in criticism in its estimation of Hopkins as a scientifically informed writer, at least in his years post-Stonyhurst. Accordingly, this dissertation will present readings of Hopkins' poetry and prose in light of developments in Victorian energy physics. Three claims will span the chapters pertaining to Hopkins' oeuvre: First, that Hopkins' distinctive terminology of stress and instress expresses the energetic relations between objects. Second, that Hopkins' metaphors and analogies are unusual in that they often signify literal relationships between things compared, particularly when metaphysical forms of stress or instress are likened to physical forms of energy. And third, that in Hopkins' writings the natural world and the supernatural order of creation are contiguous, and that energy suffuses both.

For students of Victorian literature and culture generally, claims as to the interrelation of art, science, and culture amount to truisms by this point, thanks to the seminal work of such scholars as Gillian Beer, Michel Serres, N. Katherine Hayles, George Levine, Daniel Brown, Jude Nixon, Tom Zaniello, Barri Gold, and others. Nevertheless, the specific ways that art and science interpenetrate continue to fascinate. This dissertation will discuss several interpenetrations between culture and art and culture and science in the writings of Gerard Manley Hopkins, as well as of W. J. M. Rankine, William Thomson, and P.G. Tait.

Specifically, chapter 2 addresses the developing register of physical science in the nineteenth century. This chapter focuses on two terms, stress and strain, and traces their development within nineteenth century scientific writings, beginning with the works of John Robison, Peter Barlow, Olinthus Gregory, John Frederick William Herschel, and Michael Faraday, and ending with William John Macquorn Rankine's redeployment of stress and strain as critical terms for 1850s mechanics and thermodynamics. In explicating Rankine's usage, this chapter emphasizes Rankine's appropriation of stress to denote an object's internal strength as an expression of its material form.

From the perspective of science history, the development of stress and strain is interesting in its own right. However, chapter 3 turns from science history to literary history, and addresses the importance of this development for the poetry and prose of Gerard Manley Hopkins. In comparing Hopkins' usage of instress, outstress, stress, and strain against the context of nineteenth century science writings, chapter 3 will argue that the terms central to Hopkins' poetics can be understood as an imaginative reinterpretation of contemporary science. While many critics have explicated the significance of Hopkins' stress, strain, and instress, only Daniel Brown has systematically compared Hopkins' terms to the evolving registers of nineteenth century engineering and thermodynamics. Chapter 3 extends from Brown's exemplary history, situating Hopkins' writings in their Victorian context and exploring several passages from his poems and other writings for additional nuance.

Chapter 4, "Metaphor vs. Metonymy: Hopkins' Figures of Stress," assesses Hopkins' imagery and figurative tropes. This chapter applies Roman Jakobson's and Paul Ricoeur's structuralist theories of language, particularly as integrated by Raymond J. Wilson. Compared to these theorists' descriptions, Hopkins' metaphors are unusual because tenor and vehicle lack the "absurd" difference characteristic of most metaphor. Instead of difference, Hopkins' metaphors function through similarity. Accordingly, his comparisons between spiritual and physical stress suggest that he considered the physical and the metaphysical realms to operate by the same laws of energy, particularly the laws of thermodynamic "energetics" that had been defined by Victorian physicists in the 1850s. To support this reading, the chapter examines Hopkins' poems "As Kingfishers Catch Fire" and "God's Grandeur."

In treating the metaphysical world as an extension of the physical, Hopkins resembles a number of other Victorian writers, scientific and popular alike. To demonstrate the identity of spiritual "energy" with natural forms of energy, chapter 5 compares Hopkins' psychology to nineteenth century brain science, as well as his commentary on Ignatius' "Meditation on Hell" to contemporary physical models of energy and aether. Specifically, the chapter argues that for Hopkins, thought and memory were not disembodied mental processes but a matter of energy within the brain. Likewise, in Hopkins' descriptions of the soul, the soul acts by exerting a field of force similar to the electrical or magnetic fields studied by Victorian scientists such as Faraday, Maxwell, or Lodge.

Before going further, I will briefly sketch some of the major developments in nineteenth century physical science. This sketch will introduce readers unfamiliar with nineteenth century science to important concepts, figures, and vocabulary necessary to follow the discussion of subsequent chapters. It will also indicate in a preliminary fashion several instances of reciprocal influence between science and broader Victorian culture.

1.1 Energy Science in Victorian England

In broad strokes, the Victorian understanding of energy consists of two propositions, known as the first and second laws of thermodynamics. The first law explains that while energy may change form – from heat to work, electricity to heat, magnetism to electricity, etc. – it cannot be created or destroyed. Thus, the total energy in the universe remains constant, even though it may shift from one form to another. The second law balances the first, and explains that while energy cannot be created or destroyed, the total useable energy in the universe is constantly decreasing. Energy "flows" from high concentrations to low concentrations, and once the energy gradient of a system has equalized, transfer of energy within that system ceases.

But the understandings summarized as the laws of thermodynamics developed over an extended period of time between the late 1700s and the early 1850s. As I will explain below, in several respects the Victorian science of energy (otherwise known as thermodynamics) stems from industry, the steam engine specifically. But in another respect, it also emerges from a train of scientific experiments that demonstrated the interconvertibility of nature's energies. Taken together, the applied study of the steam engine and the experimental demonstrations of energy conversion supplied the matrix from which William Thomson and Rudolph Clausius derived the laws of thermodynamics in the 1850s. Below, I will summarize some of the scientific experiments before reviewing the study of the steam engine.

One of the first insinuations of interconvertibility of nature's energies dates to 1798, when Count Rumford (Benjamin Thompson) read his "An Inquiry Concerning the Source of the Heat which is Excited by Friction" to the Royal Society. Rumford was an American Tory "knighted by George III for his loyal service during the American Revolution" (Smith 67). After the war, Rumford travelled to Bavaria at the request of Prince-elector Charles Theodore, where he oversaw the modernization of the Bavarian army. For his service, Rumform was made a count of the Holy Roman Empire, and took the title of Count Rumford. Back in England, Rumford, along with Sir Joseph Banks, established the Royal Institution in 1799, an institution that would provide the livelihood of such eminent men of science as Humphrey Davy, Michael Faraday, and John Tyndall.

At one point in his 11-year stay in Bavaria, Rumford measured the heat produced as his men bored cannon barrels. Rumford observed that friction engendered the heat, and postulated the interconvertibility of work and heat. Rumford's theory was set aside by his contemporaries for a number of reasons, however, primarily because he argued that heat was not a substance itself but a form of motion within a substance (in modern scientific terms, we would say that heat is molecular vibration). At the time, natural philosophers commonly took heat to be an imponderable substance (caloric) that could not be weighed or perceived, but that nevertheless existed materially. Rumford, in claiming that friction generated heat, violated this doctrine, and his postulated conversion of work to heat was consequently discounted.

In 1799, Humphrey Davy defended his benefactor's claims by rubbing two pieces of ice together until they melted. Since ice cannot be said to contain an abundance of caloric – the fact that ice forms only at low temperatures discourages such a claim – partisans of the caloric theory of heat could not argue that rubbing the ice had "liberated" the caloric stored within it. The only available alternative was that friction induces heat, and that heat itself, far from being an actual substance, is a measure of the motion (in modern terms, the molecular vibration) of the particles within a substance. Thus, friction or mechanical work induces the particles of a body to vibrate, and this vibration registers as heat. Heat and mechanical work are fully interconvertible.

Other conversions multiplied in the half-century between Davy's experiment and Joule's work in the 1840s. In 1820, Hans Christian Ørsted (Oersted) noticed that an electric current could deflect a magnetic needle. The fact that magnetism and electricity interacted suggested a close relationship between them, and perhaps even a common origin. Accordingly, philosophers began to consider whether the two forms of energy were simply a single energy variously expressed.

Michael Faraday, working out of the Royal Institution, clinched the question in 1831when he discovered electromagnetic induction. In a series of experiments, Faraday proved that magnets could cause – "induce" – an electrical current in a wire. If magnetism could cause electricity, then the two forms of energy were intrinsically related.

In another experiment fourteen years later in 1845, Faraday proved the interaction of light and magnetism. Faraday positioned two electromagnets in such a way that the lines of force connecting them were parallel with a ray of polarized light. When Faraday sent current through the electromagnets, the resulting magnetic field caused the plane of polarization in the ray of light to rotate. With this experiment Faraday demonstrated that magnetism affects light. As with his earlier experiment, the fact that different forms of energy impinge on each other suggests, at the least, a correspondence between them. But more than mere correspondence, such experiments tantalized physicists with the possibility of a deeper ontological identity common to all manifestations of energy. In the words of a paper Faraday read to the Royal Society in November of 1845,

> I have long held an opinion, almost amounting to conviction, in common I believe with many other lovers of natural knowledge, that the various forms under which the forces of matter are made manifest have one common origin; or, in other words, are so directly related and mutually dependent, that they are convertible, as it were, one into another, and possess equivalents of power in their action. (1-2)

Other investigators arrived at similar conclusions. Thomas Kuhn identifies four investigators – Sadi Carnot, Mark Séguin, Karl Holtzmann, and G. A. Hirn – who between 1832 and 1854 "recorded their independent convictions that heat and work are quantitatively interchangeable" (67).[1] Kuhn also names four other "widely scattered European scientists – Mayer, Joule, Colding, and Helmholtz," who considered not just heat and work to be convertible, but all forms of energy generally, and who proposed quantitative conversion formulae to calculate the amount of one form of energy that could be produced from a given amount of

[1] Given Carnot's conception of heat "flow" in *Reflections on the Motive Power of Fire* (see below), Kuhn's announcement may be surprising. However, Kuhn observes that Carnot's thinking had evolved between his early *Reflections* and his later work. Based on an unpublished notebook written "between the publication of his memoir in 1824 and his death in 1832," Kuhn argues that Carnot did at last conceive of the production of work from heat as a true conversion (67, note 2). Kuhn invites readers to "notice that Carnot considered the material in these notes quite incompatible with the main thesis of his famous *Réflexions"* (67, nt. 2).

another (67). Finally, Kuhn lists four additional figures (Mohr, Grove, Faraday, and Liebig) who, although they did not propose quantitative conversion formulae, nevertheless “described the world of phenomena as manifesting but a single ‘force,’ one which could appear in electrical, thermal, dynamical, and many other forms” (68).

Kuhn’s point is that between the 1830s-50s, “the climate of European scientific thought included elements able to guide receptive scientists to a significant new view of nature” (70). He observes that several of the scientists mentioned above worked “in complete ignorance of the others,” and that their near-simultaneous discoveries should not be considered the product of specific influence so much as the result of the general condition of science at the time (66). Particularly, Kuhn specifies three characteristics of mid-century science that account for the sudden and simultaneous burst of conversion theories: “the ‘availability of conversion processes,’ the ‘concern with engines,’ and the ‘philosophy of nature’” (73).

Yet while many scientists shared the conviction that the energies of nature were manifestations of a single, pervasive power, two stand out for translating their convictions to testable, quantifiable terms.[2] The priority of Julius Robert Mayer and James Prescott Joule has been much debated from 1862 until the present.[3] Mayer was the first to calculate the amount of

[2] In the passage that I quoted above from Kuhn, Kuhn identifies four figures who posited quantifiable conversion figures between various types of energy. However, Colding and Helmholtz followed Mayer in calculating their equivalents, and unlike Joule, they did not confirm their calculations experimentally.

[3] The priority dispute of Mayer vs. Joule was one of the shibboleths in the power struggle between the agnostic X Club and the devout North British School. The X Club comprised Thomas Henry Huxley, John Tyndall, Joseph Dalton Hooker, Herbert Spencer, and others, while the North British School included William Thomson, James Prescott Joule, P.G. Tait, James Clerk Maxwell, W. J. M. Rankine, William Rowan Hamilton, and James D. Forbes. These cabals fought for the right to interpret the cultural meaning and influence of science: the X Club fought to enlist science to the cause of secular naturalism, while the North British School fought to interpret science to reveal God’s order and design in nature. Both groups sought to discredit members of the other faction, and even to block them from university appointments and

heat generated by a given amount of work. But Mayer derived his conclusions mathematically, and did not prove them through experiment. Joule, however, arrived at his "mechanical equivalent of heat" through a series of experiments, and is usually credited with proving definitively that heat and work are convertible.

As a young man, Joule studied arithmetic and geometry under John Dalton (Smith 56). Crosbie Smith remarks that Joule's characteristic esteem for quantitative measurement and experimentation may be an inheritance from his master. Additionally, as the son of a brewer, and subsequently as the owner of his family's brewery, Joule's occupation rewarded precise measurement. The brewery also afforded Joule space to work – it was his laboratory, and his men his laboratory assistants.

In his most famous experiment, Joule constructed a brass container, and filled it with water. Inside the container, Joule set a thermometer, and rigged "a set of paddles, driven by cords attached to falling weights" (Hunt 33). The weights drove the paddles, which threshed the water. The friction of the paddles in the water translated to heat. As the water warmed, Joule's thermometer registered the change in temperature. By comparing the force produced by the falling weights to the number of degrees by which the water warmed, Joule was able to establish an accurate equivalence between mechanical force and heat – "782 foot-pounds of work raised the temperature of a pound of water by 1° F" (Hunt 33).[4] Joule not only demonstrated the qualitative equivalence of work and heat, but he also enabled quantitative estimates of the amount of work that could be derived from heat, or vice versa.

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professional honors. In the present case, John Tyndall (an X Clubber) attempted to undermine the claim of James Prescott Joule (a North Britisher) to have been the first to ascertain experimentally the mechanical equivalent of heat. Please see Ruth Barton's "Scientific Authority and Scientific Controversy in *Nature*: North Britain against the X Club" in *Culture and Society in the Nineteenth-Century Media*.

[4] Joule later revised his results from 782 foot-pounds to 772.

The train of scientific experimentation from Rumsford to Joule accounts for one vector of thermodynamic theory. But thermodynamics also has its roots in the industry of the preceding century. Bruce J. Hunt and Crosbie Smith observe the especial importance of the steam engine in the production of scientific knowledge, arguing that the technology of steam preceded the science required to understand it. As engineers and scientists strove to understand the steam engine's operation and to make it work more efficiently, they were forced to consider the way energy worked within the machine. Particularly, they were forced to consider the irreversible operation of the machine, or the irreversible directionality of energy within the machine. This consideration revealed a property of energy that had not appeared in the laboratory experiments of other scientists: namely, entropy. In Hunt's words, "the story of the steam engine and the birth of thermodynamics provides a clear illustration of the chief theme of [his] book: that technology is not simply 'applied science' but has often taken the lead and shaped the development of scientific knowledge" (4).

While British and German natural philosophers attempted to discover the ways one form of energy converted to another, the French engineer Sadi Carnot investigated the limitations of energy transfer. Carnot's main thesis was that heat in a steam engine transfers from a hot body to a cold body. A hot body will never become hotter by touching a cold body. When a hot body touches a cold body, heat does not flow from cold to hot, but from hot to cold. Accordingly, when hot and cold bodies touch, their temperatures equalize. When the formerly hot and the formerly cold body reach the same temperature, net energy flow ceases. Once this happens, the machine stops.

Carnot's thesis sounds simple, but it has several profound applications for steam engines and for physics in general. For the steam engine, Carnot insisted that the best way to improve the efficiency of the engine was to keep the hot boiler completely separate from the cool condenser. If energy transfer (hence the power of the engine itself) approaches zero as the hot and cold parts of the machine approach each other in temperature, then the best way to ensure the engine's power is to keep hot parts hot, and cold parts cold. Carnot particularly stressed that no hot part of the machine should ever make contact with a cool part of the machine. Such contact sapped the machine of its strength, and uselessly squandered its motive power without producing any beneficial work. Instead, engineers should use every trick of the trade to buffer, insulate, sleeve, and separate hot and cold parts. In all, engineers should ensure that every diminution of the machine's heat produced work. Heat must necessarily flow from the hot boiler to the cool condenser, but engineers should squeeze every possible bit of work out of the process. Not only would doing so improve the engine's power, but it would also improve its efficiency, making it require less coal to perform the same work.

Given the expense of coal, Carnot's ideas – once popularized by British physicists such as William Thomson and implemented by engineers like W. J. M. Rankine – would significantly reduce industrial expense. But his ideas had an even larger effect on physics and culture, as we shall see shortly. The laboratory scientists discovered the ways energy shifted and transferred between forms, but the steam engine and Carnot showed energy's limitations. Namely, within any given system, energy flows from high to low. It is impossible, without exerting work from without the system, to reverse the flow of energy and send energy from an unenergetic object back to an energetic object. Moreover, as energy flows from high to low, the difference between the two objects decreases – the unenergetic object becomes more energetic; the energetic object becomes less energetic. As this process continues, the rate of energy transfer decreases, and ultimately stops when the system reaches equilibrium, or when all objects in the system have reached an equal degree of energy.

In this process of equilibrium, the total amount of energy does not matter so much as the total difference between energetic and unenergetic parts. For example, an engine whose boiler works at 1500 degrees Fahrenheit will still stop if its condenser also reaches 1500 degrees Fahrenheit.[5] Although the machine possesses an immense store of energy, the energy has been evenly dispersed, and is incapable of flowing through the machine. In effect, the energy has been bound up and made unavailable for use. Contrarily, an engine whose boiler works at only 300 degrees Fahrenheit will perform splendidly if its condenser is kept to, say, 100 degrees. This machine has much less total energy, but the differential between hot and cold parts enables energy to flow from boiler to condenser, and to do work in the process. The latter machine has much less total energy, but much more available energy. Essentially, Carnot's work deals with the latter factor instead of the former, or with available energy instead of total energy.

Between 1849 and 1851, in a fundamentally critical exchange between the British physicist William Thomson and the German physicist Rudolph Clausius, the engineering tradition represented by Carnot would at last meet with the philosophical tradition spanning from Rumford to Joule. Thomson' part of the exchange survives in the form of two papers, "An Account of Carnot's Theory" (1849) and "On the Dynamical Theory of Heat" (1851). Clausius' part persists as "On the Motive Power of Heat" (1850). In this exchange, Thomson and Clausius reconciled the philosophical and engineering traditions to form two complementary principles. These principles would be fleshed out, revised, and refined over the next two decades by

[5] My example is meant to illustrate a point, not to represent reality. Only boilers are constructed to reach such temperatures (and accompanying pressures). In reality, if the condenser of a steam engine reached anywhere near such a temperature, it would catastrophically fail.

Thomson and Clausius themselves, as well as by W. J. M. Rankine and other physicists. Along with Rankine's theoretical contributions, his redefinitions of stress and strain and his coinages "potential energy" and "actual energy" furnished energy theorists with a tightly defined vocabulary to aid the necessary interchange of ideas (see chapter 2).[6]

Thomson and Clausius' first principle, later known as the first law of thermodynamics, summarized the findings of Rumford, Davy, Ørsted, Faraday, Mayer, Joule, and other natural philosophers. According to this principle, the various forms of energy in nature may alter and interconvert, but to use the words of Clausius' 1864 statement of the first law, "the energy of the universe is constant" (*Mechanical Theory* 365). Although electricity, heat, work, magnetism, and light may shift into one another, the universe conserves its total energy nevertheless. However, the second principle, later the second law of thermodynamics, develops Carnot's observation. Energy may shift back and forth between its various forms, but it travels in only one direction – from high concentrations to low concentrations. Ultimately, energy tends toward equilibrium. As a system approaches equilibrium, its energy becomes less and less available for use. Finally, when equilibrium is achieved, all energy transfer stops. Clausius coined the term "entropy" to designate the amount of bound energy in a system, or the amount of energy unavailable for work. Thus, as a system nears equilibrium, its available energy decreases, and its entropy increases. As Clausius later stated the second law of thermodynamics in 1864, "the entropy of the universe tends toward a maximum" (*Mechanical Theory* 365). Restated, the second law describes the universal trend of energy towards equilibrium, when no energy will be left available for use.

[6] For a seminal account of Rankine's involvement with Clausius and Thomson in developing the theory and lexicon of thermodynamic science, see P. M. Harman's *Energy, Force, and Matter: The Conceptual Development of Nineteenth-Century Physics.*

Depending on the system, the implications of the second law range from the trivial to the apocalyptic. In the system of a steam engine, temperature equilibrium between boiler and condenser results in the machine losing power and stalling. In a solar system, however, or in the universe itself, energy equilibrium results in stasis and death.

The chilling import of thermodynamics augmented the cultural influence of the physical sciences. Victorians regarded the sibylline prophesies of the new energy science with fearful fascination. Thomson himself published an article entitled "On the Age of the Sun's Heat" (1862) in *MacMillan's Magazine* estimating the length of time which the sun would continue to heat and light the earth (see chapter 4). Thomson's conclusion stimulated religious faith while stoking apocalyptic fears: "As for the future, we may say, with equal certainty, that inhabitants of the earth cannot continue to enjoy the light and heat essential to their life for many million years longer unless sources now unknown to us are prepared in the great storehouse of creation" (393).

The number and quality of mainstream Victorian authors who integrated thermodynamic theory within their works attests the popular importance of the discourse. Barri Gold traces the thermodynamic resonance of Tennyson's *In Memoriam*, Charles Dickens' *A Tale of Two Cities*, Bram Stoker's *Dracula*, and Oscar Wilde's *The Picture of Dorian Gray.* Additionally, Jessica Kuskey reads Dickens' *Our Mutual Friend* as a literary model of a steam engine, Tina Young Choi observes the implications of thermodynamics' first law for *Little Dorrit* and *Our Mutual Friend*, and Darryl Jones compares *Bleak House* against the thermodynamic narrative of the "death of the sun."[7] Moreover, Jude Nixon probes Carlyle's prose for thermodynamic parallels, and Barbara Lindquist investigates gender in Theodore Dreiser's *Cowperwood* trilogy along

[7] Dickens was at the center of several developments in physical science. As part of a public battle between the devout North British School and the agnostic, naturalist X Club, P.G. Tait and William Thomson published an article in Dickens' *Good Words* attacking John Tyndall. See Crosbie Smith's "North Britain versus Metropolis" in his *The Science of Energy*.

thermodynamic lines. Steve Pinkerton considers the import of the second law of thermodynamics in James Joyce's *Ulysses*. Sarah Alexander contemplates Arthur Morrison's *A Child of the Jago* as an "entropic narrative." Gillian Beer applies thermodynamic theory to the works of Thomas Hardy.

Yet few authors deploy the science of energy so systematically and to such transcendent extent as did the poet of instress, Gerard Manley Hopkins. In his central poetic theory, neologisms, imagery, themes, and mythos, Hopkins refashions thermodynamic physics as a divine system of stress subsuming nature in Christ. Specifically, in Hopkins' mythos of the Great Sacrifice, Christ progressively incarnates himself within matter, producing the natural world as a byproduct of his Incarnation and charging it with his divine stress or "outstress." In the following chapters, we will explore the thermodynamic register of Hopkins' terms stress and instress, as well as the significance of his energetic imagery.

But before we do so, a brief overview of Hopkins' knowledge of physics is in order. Concerning his knowledge of science, Hopkins' biography becomes more conclusive as he ages. One of Hopkins' earliest notebooks, since designated "B.I" by his biographers, contains notes from a Highgate (pre-Oxford) course on "mechanics and trigonometry" (*Oxford Essays* 3). Before Oxford, then, Hopkins was familiar with at least the rudiments of mechanics, the mathematical study of the distribution of stress or force. Nevertheless, while mechanics contributed to the physical study of energy (mechanical force is one form of energy, and the steam engine for one translates heat to mechanical force), we cannot be sure that Hopkins understood the relations between mechanics and thermodynamics from this course.

Evidence from Hopkins' time at Oxford (1863-7) suggests that he continued to encounter physical science. In his Oxford essay "The Tests of a Progressive Science," for instance, Hopkins makes explicit reference to spectroscopy. Illustrating the difference between scientific stasis and progress, Hopkins writes,

> Thus the discovery between a new species of willow or the observation of parthenogenesis in aphides two generations longer than had before been found possible shews little progressiveness in science; on the other hand the spectral analysis by wh. the chemical composition of non-terrestrial masses is made out is a development of optics wh. cannot be called supplemental but a complete widening or alteration of its beat. (*Oxford Essays* 286)

Leslie Higgins traces Hopkins' references to spectroscopy to a series of articles published in *Frasier's Magazine*, particularly an article published in 1861 entitled "The Progress and Prospects of Astronomy" (*Oxford Essays* 287, n. 2). As Hopkins describes, Victorian astronomers used spectral analysis to identify the chemical constitution of distant stars. When combusted, chemical elements give off signature waves of light. The distinct colors of these lightwaves may be observed by the human eye with the help of a prism. When the lightwaves pass through the prism, the prism refracts each wave differently, displaying the lightwaves in an orderly fashion as a spectrum of color. The color spectrum for each chemical substance is unique. As such, the chemical substance of stars hundreds of light years away may be identified by the signature spectrum of color its light produces.

Essentially, then, the science of spectroscopy applies the first law of thermodynamics to chemistry, identifying a substance's chemical composition from the light it emits when it combusts. Thus, spectroscopy evidences the reciprocity of chemical and light energy. Once more, however, while spectroscopy and thermodynamics are essentially related, we have no hard proof that Hopkins understood the relation.

But the evidence mounts. Daniel Brown observes that "by the time that Hopkins began his studies at Oxford the principle of the conservation of energy was widely discussed and had been applied to many phenomena" (Brown 193). Brown discusses two articles, entitled "Energy" and "The Dynamical Theory of Heat," that P. G. Tait wrote for the May 1864 and February 1865 issues of the *North British Review* (Brown 194). Hopkins was certainly reading the *North British Review* during this time. His private journals mention an article about Wordsworth's poetry published in the August 1864 issues of the *North British Review* by J. C. Shairp. But while Hopkins read Shairp's article in the August 1864 issue, we cannot be certain that he saw the May 1864 or February 1865 issues, nor whether he read Tait's articles in these issues.

Brown continues, however, and observes that thermodynamics informs one of the textbooks that Hopkins "crammed" for Greats examinations, J. S. Mill's *System of Logic.* In an appendix to this ponderous volume, Mill discusses recent developments in physical science, observing that "It has of late become the general belief of scientific inquirers that mechanical force, electricity, magnetism, heat, light, and chemical action (to which has subsequently been added vital force) are not so much causes of one another as convertible into one another; and are all of them forms of one and the same force, varying only in outward manifestations" (Mill 1120-1). In post-1865 versions of *System of Logic*, Mill's *The Correlation and Conservation of Forces: A Series of Expositions* also appears in this appendix.

Once more however, while Hopkins certainly would have studied Mill's book, no evidence exists to prove that he read the appendix. As Hopkins' close friend Robert Bridges reports, Hopkins felt no need to read a book in its entirety. At one point, Hopkins stayed with Bridges to study for the upcoming Greats examination. Bridges dutifully read assigned texts from cover to cover. Hopkins, however, took his time with passages he felt were particularly important, scrutinizing them for hours and examining them in precise detail. Hopkins' acute methods of study prevented him from reading the whole text.[8] If we extrapolate the same reading strategy to Mill's *System of Logic*, it is likely that while Hopkins studied portions of Mill's book with piercing intensity, he probably did not read everything in the tome.

Hopkins' tutors afford another potential source of physical science. Brown observes that Hopkins may have learned the rudiments of Victorian energy science from his tutor Walter Pater, or from T.H. Green and Benjamin Jowett. Brown reads the lectures of the latter two from a thermodynamic perspective, finding the new physics of energy at work in Jowett's characteristic explanation of 'the Hegelian vibration of moments' and Green's account of the Hegelian Worldspirit as 'the energy of the world, related like motion to matter' (Brown 195).

Again, though, there is no way to prove that Hopkins picked up on Green's and Jowett's insinuations. Accordingly, the evidences from Oxford, though numerous and (to me) convincing, lack the hard proof that would set them beyond contradiction. Yet following his graduation from Oxford, the evidence becomes more concrete, and Hopkins' knowledge of physics becomes more certain.

After his time with Newman in the Birmingham Oratory (1867-8), Hopkins toured the Alps with his friend Edward Bond before entering the Jesuit Novitiate (1868). At one point, he met Tyndall himself "at the foot of the Matterhorn" (*Further Letters* 128).[9] Bond was sick, and Tyndall "very kindly saw E.B. and prescribed a treatment" (*Journals* 182).

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[8] Incidentally, Hopkins achieved a brilliant first on his Greats examination. Bridges achieved a respectable second.

[9] Tyndall was a famous Royal Institution physicist, the protégé of Michael Faraday. As a member of the X Club, Tyndall participated in serial skirmishes with the North British School. Particularly, Tyndall was the primary target of Thomson and Tait's ire for touting Mayer as the originator of the mechanical equivalent of heat instead of Joule. Gillian Beer argues that Hopkins' "The Virgin Mary Compared to the Air we Breathe" was inspired in part by Tyndall's

But even still, Hopkins' encounter with a famous scientist does not prove that Hopkins understood the science for which the scientist was famous. Thankfully, evidence continues to mount. By the time of Hopkins' Stonyhurst Philosophate (1870-73), the evidence is very good that Hopkins was well acquainted with physical science. During these years, Hopkins read the scientific journal *Nature,* still considered to be one of the flagship journals of the physical sciences. P. G. Tait, William Thomson's friend and co-author of the influential *Treatise on Natural Philosophy*, frequently contributed articles to the journal, as did Tyndall and other notable Victorian physicists such as Norman Lockyer and Balfour Stewart. In fact, the quarrel between Tait and Tyndall over the priority of Joule vs. Mayer – and more generally, the struggle for influence between the X Club and the North British School -- boiled over into *Nature.*[10]

Moreover, at Stonyhurst itself, Hopkins studied with Fathers Stephen Perry and Walter Sidgreaves of the Stonyhurst Observatory. According to Tom Zaniello, the Stonyhurst Observatory was "one of [England's] leading meteorological stations," and Father Perry, the observatory's director, was the "foremost Victorian astronomer" ("Scientific Interests," 511; "An Attentive Observer," 326). Perry specialized in solar and magnetic phenomena, and his "magnetic surveys were standards in the field" ("An Attentive" 327). Moreover, Zaniello states that Perry's popular lectures on spectroscopy packed houses, and at times attracted as many as 1,000 people to hear the renowned astronomer speak (327). With Perry as a friend and mentor, it seems inconceivable that Hopkins could have remained ignorant of the basic principles of physics. Not only are magnetism, spectroscopy, and astronomy subfields of physics, but the various forms of energy involved in these subfields were centrally important to the development

investigation of the behavior of light in the earth's atmosphere. See her "Tyndall, Helmholtz, and Gerard Manley Hopkins: Leaps of the Prepared Imagination."

[10] See above, footnotes 7 and 11. For a more complete description, see Ruth Barton's "Scientific Authority and Scientific Controversy in *Nature*: North Britain against the X Club."

of thermodynamics. As discussed previously, Oersted's and Faraday's research of the interconvertibility of magnetism and electricity, and Faraday's discovery of the interaction of magnetism and light, were critically important in Thomson's and Clausius' articulation of the first law of thermodynamics. Furthermore, spectroscopy enquires into the fundamental association of light and chemical energy. Pertaining to astronomy itself, astronomers study gravity and light as subfields proper to their discipline. Magnetism, chemistry, light, gravity – Perry's worked encapsulated the various forms of energy reconciled by the first law of thermodynamics. Accordingly, Hopkins' friendship with and tutelage under the respected astronomer marks the endpoint when his knowledge of physical science can reasonably be doubted.

By the time Hopkins resumed writing poetry at St. Beuno's (1874-7), he was well acquainted with contemporary physics.[11] Critics may debate the extent of Hopkins' knowledge pre-Stonyhurst, but few dispute that he knew physics post-Stonyhurst. In sum, while thermodynamic interpretations of Hopkins' Oxford poems are not impossible (Jude Nixon, Gillian Beer, and Marie Banfield make cautious thermodynamic readings of Hopkins' Oxford poems, while James Leggio and Daniel Brown offer much more aggressive readings), they should be prefaced with a biographical defense. But from *The Wreck of the Deutschland* and on, Hopkins' knowledge of Victorian physics is quite certain. Indeed, Hopkins is most likely more knowledgeable of contemporary physics than the twenty-first century critics who read his poems. Not only did Hopkins have the advantage of belonging to the culture that produced these scientific developments, but few twenty-first century critics can boast having an "internationally-

[11] Hopkins' enrollment at St. Beuno's proceeds the composition of what are commonly considered his mature poems. *The Wreck of the Deutschland* is generally considered the first notable poem composed after Hopkins' entered his St. Beuno's Theologate.

known" astronomer as a personal friend and "mentor in matters scientific" ("An Attentive" 326; "Scientific Interests" 511).

During Hopkins' second stay at Stonyhurst from 1882-4, he began a serial correspondence of four letters published in the scientific periodical *Nature.* In the pages of this prestigious scientific organ, Hopkins' words and letters mingled with those of England's most highly-regarded physicists, including P. G. Tait, Balfour Stewart, Norman Lockyer, and John Tyndall. Hopkins' letters describe atmospheric phenomena, particularly the English sky shortly after the Krakatoa eruption. While these letters do not entertain any deep physical arcana, they do showcase his powers of observation, as well as his poet's facility to phrase physical sensation in exquisitely precise and memorable language. Hopkins' letters earned the praise of the Royal Society itself. In its survey of published literature pertaining to the Krakatoa eruption, the Royal Society report mentioned a "Mr. Gerard Hopkins of Stonyhurst College" and particularly observed his "very lucid description of the sunset of December 16, 1883" (Symons 172).[12]

From Dublin (1884-9), Hopkins discusses with his friend R. W. Dixon his plans to write a "popular account of Light and the Ether," using P. G. Tait's *Light* as his main source (*Correspondence* 139). By this time, Hopkins has become sufficiently confident of his grasp of physics that he hopes to "make the matter [. . .] perfectly intelligible" (139). Hopkins does not intend his book to be "easy reading," but writes it for "the lay or unprofessional student who will read carefully so long as there are no mathematics and all technicalities are explained" (139). The science of light and aether were essential components of thermodynamic theory (see chapter 5). As such, by this point Hopkins considers himself to be sufficiently knowledgeable about thermodynamic science to translate its arcana into plain English for diligent readers.

[12] See Monique Morgan's account of artistic responses to the Krakatoa eruption in her "The Eruption of Krakatoa (also known as Krakatau) in 1883."

Unfortunately, like so many of Hopkins' other Dublin projects, the popular account of light and aether was never completed, or if it was, it has since been lost. Nevertheless, in Hopkins' extant writings, in his poetry, journals, and spiritual notebooks, Hopkins translates the arcana of thermodynamics into an equally arcane mystery of spiritual instress and Incarnation.

To this mystery we now turn. Chapter 2 will address the evolution of stress and strain within nineteenth century physical science. Subsequently, chapters 3-5 will trace the thermodynamic implications of stress for Hopkins' poetry and prose.

2 STRESS AND STRAIN: RANKINE'S CONTRIBUTIONS TO THE SCIENTIFIC REGISTER

In his seminal 1957 article "Energy Conservation as an Example of Simultaneous Discovery," Thomas Kuhn examines the preconditions of scientific discovery, or surveys the "experimental and conceptual elements" that necessarily precede the development of new scientific theories. Kuhn expressed his aim as identifying "the rapid and often disorderly emergence of the experimental and conceptual elements from which [scientific] theory was shortly to be compounded" (323).

Kuhn in this essay specifically addresses the preconditions of energy conservation, but more broadly his methodology partakes of a general trend in science history to consider past scientific work within its own context as opposed to current scientific understanding. If the scientific historian's traditional occupation has been to link present to past by tracing the lineal ancestry of contemporary scientific theory, such an enterprise as Kuhn adopts poses a second historical aspiration, that of explaining not so much how past theories have led to present knowledge but how those theories emerged in the first place from knowledge that was then available. In broad form (and arguably in a broader form than Kuhn himself pursued), this aspiration motivates interest in theorists whose ideas have been disproven, and in scientific understandings that contemporary theory and practice reject. Far from unprofitable, such theorists and understandings are regarded by culture critics as simultaneously products and productive of the intellectual milieu of their era, and by more discipline-conscious historians as contributing – albeit in a negative or apophatic sense -- to a conversation that would ultimately conduce to scientific knowledge.[13]

To this trend William John Macquorn Rankine owes his recent rebound in critical attention. Writing in 1981, Keith Hutchison observed that "to contemporaries, thermodynamics was a creation of [William Thomson, Rudolf Clausius, and W. J. M. Rankine]" (1). Given Rankine's standing in his own time, Hutchison asks, "Why is [Rankine's work] now so little known?" (1). Hutchison intends his answer to reveal as much about the nature of science historiography as it does about the quality of Rankine's contributions to science. Regarding the latter, Hutchison explains that "Rankine's contributions to theoretical thermodynamics as it *finally* emerged were minimal" (1). Hutchison, however, is quick to point out the anachronistic fallacy of such thinking, arguing that an account of the history of thermodynamics that neglects Rankine is unfaithful to history itself not only in that it is "difficult to reconcile with the primary sources, where Rankine is so often referred to," but also in that it "involve[s] a considerable misrepresentation of the thought of the 1850s" (20).

[13] In seeking to recover the milieu productive of past scientific understandings, recent science history in many senses resembles cultural criticism. The association should not be pushed too far in every case, however. Kuhn in particular argued that science breakthroughs and revolutions are best understood from within the tradition of science itself, not from external culture. See for instance his *Structure of Scientific Revolutions*.

Preceding Hutchison, but, if anything, emphasizing Rankine's influence more pointedly, Donald Moyer in 1977 surveyed the trope of mechanical analogy in the publications of Rankine, Thomson, Tait, and Maxwell. In contrast to traditional estimations of scientific priority, Moyer boldly places Rankine at the head of a chain of influence uniting the four philosophers. While Moyer does not claim that Rankine preceded Thomson in articulating a specific theory, he nevertheless argues that Rankine provided Thomson, Tait, and Maxwell with an analytical method or pattern of thinking that freed them from dependence on mechanical explanations of phenomena and consequently enabled them to prosecute their respective theories. Moyer explains that in his 1853 *Outlines of the Science of Energetics*, Rankine – most likely plagued by the inherent improbabilities of his own theory of molecular vortices – attempted to account for physical phenomena not by the laws of mechanics but by the emerging laws of energy. Given that the laws of energy are expressed in the general behavior of matter, an "energetic" philosopher could henceforth explain phenomena according to matter's general behavior instead of its hidden mechanical causes. In other words, philosophers of the new science of energetics were no longer bound to express with their models the causes of phenomena. Instead, they could focus on replicating the phenomenon itself: given that the same laws of energy governed the model, the phenomenon, and the phenomenon's cause, the model would possess at least an analogical relationship to reality.

In short, Rankine's tactic alleviated physicists of the onus of explaining observed phenomena by mechanical causation. Scientific models could now function as approximations of reality, not actual representations of it, and could be employed as useful fictions to enable the mind to grasp theoretic concepts. Even if the model proved inapposite to reality, it could be profitable if it expressed the general behavior of phenomena, which in turn expressed the behavior of energy itself. Such an estimate of useful fictions animates many of Thomson's, Tait's, and Maxwell's most famous scientific projections, and, even if Moyer does not mention these models particularly, his account of the influence of Rankine's figurative estimation of models explains such well-known instances as Maxwell's daemon,[14] Tait's and Stewart's unseen universe, and Thomson's vortex atoms of whirling aether.[15]

In recent years, Rankine has prompted various science historians. Those who wish to trace the development of present scientific understandings treat Rankine cursorily in footnotes and prefatory chapters, while Thomson, Clausius, and Maxwell remain central figures. Oppositely, science historians and culture critics interested in recovering the milieu from which thermodynamic theory emerged have come to regard Rankine as a central figure in Victorian science, and he has received particularly close attention in several recent works. This distinction is admittedly a generalization with several notable exceptions, but in broad strokes it holds true. For instance, in Jos Uffink's 2001 survey of interpretations of the Second Law of Thermodynamics, Uffink, in a footnote, explains "of course the work of several other authors was also highly significant, such as Rankine, Reech and Clapeyron. And although I agree with

[14] Maxwell's daemon is a make-believe being capable of reversing entropy, energy's universal trend to dissipate and disperse. In devising his uniquely-gifted being, Maxwell theorized what it would take to defeat thermodynamics' Second Law, or to spontaneously accumulate energy without expending work. Maxwell imagined a gas-filled container split by a partition into two hermetically-sealed compartments. A slide in the partition – perfectly devoid of mass or friction so as to require no work to operate – is guarded by a "very observant and neat-fingered being" that sees molecules well enough to distinguish hot ones from cool ones and flips the slide open or shut fast enough to block certain molecules while allowing others to pass (*Letters*, 332). If this "neat-fingered being" should decide to allow only hot molecules to flow into one compartment and only cool molecules to flow into the other, over time the one compartment would become very hot and the other very cool. In essence, Maxwell's talented sprite concentrates thermal energy without performing work (it should be remembered that the slide is massless and frictionless).

[15] For more about Thomson's vortex atom and Tait and Stewart's *Unseen Universe*, please see chapter 5, section 5.5.

those historians who argue that the role of these lesser known authors is commonly underestimated in the traditional historiography of thermodynamics, I will not attempt to do justice to them" (325, fn. 19).[16] Likewise, in Bruce Fegley's 2013 *Practical Thermodynamics for Geoscientists* – a book that despite its title evidences nearly as much interest in the history of thermodynamics as in its theory -- Rankine is briefly mentioned as the innovator of the Rankine scale of temperature but is excluded from later chapters explaining the development of thermodynamic theory proper. Even in Bruce J. Hunt's *Pursuing Power and Light*, a book that includes an impressive survey of the relationship between, as the subtitle tells, *Technology and Physics from James Watt to Albert Einstein*, Rankine receives hardly any attention besides a paragraph crediting him with the innovation of the terms "energy" and "potential energy."[17]

Among historians interested in recreating the mid-nineteenth century milieu for its own sake, however, Rankine has steadily accrued interest. Crosbie Smith, in his *The Science of Energy: A Cultural History of Energy Physics in Victorian Britain,* devotes nearly an entire chapter ("The Science of Thermodynamics") to Rankine, particularly investigating Rankine's close relationships with engineers in the Clyde river valley and his application of thermodynamic principles to the steam engine. Likewise, Keith Hutchison, in his "History of Thermodynamic Sciences" in the 2004 *Encyclopedia of Energy,* reserves a substantial portion of his essay to discuss the interrelations of Rankine's vortex theory with the thermodynamic theories of Thomson and Clausius. Works such as these have prompted interest in the correspondence

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[16] To be fair to Uffink, he later does discuss Rankine within the body of his article when he describes the disagreement between Rankine and Thomson and Clausius over the irreversibility of entropy (341-2). All the same, Uffink's interest in ranking scientific authors from the retrospect of twenty-first century science appears in his subordination of "lesser" authors like Rankine to the greater authors whose influence has passed to the present in the form of currently accepted scientific theory.

[17] Rankine's general absence from the book is all the more surprising given his important work with the quintessential technology of the nineteenth century, the steam engine.

between Rankine's life and the scientific achievements of his time, and Ben Marsden is slated to publish a biography of Rankine in the near future.

A small number of culture and literary critics have also tapped Rankine to elucidate the scientific context of Victorian Britain and Victorian literature. Thus, Daniel Brown explores the significance of Rankine's term stress for Gerard Manley Hopkins' "Parmenides" notes (213-5), and Marie Banfield briefly alludes to Rankine's part in developing the theory and language of energy science that she sees as operative in Hopkins' "Spelt from Sibyl's Leaves."

This and the next chapter take their cue from Daniel Brown. The present chapter proposes to trace the morphology of the terms stress and strain through the writings of nineteenth century science authors; the subsequent chapter will apply findings gleaned in the present chapter to the poetry and biographical materials of Gerard Manley Hopkins. In this enterprise, W. J. M. Rankine will be a central figure given his efforts to establish a rigorous and precise register of scientific language, particularly his self-conscious redeployment of the terms stress and strain.

Such an investigation applies to Hopkins studies in that it uncovers still more correspondence between Hopkins' poetry and the Victorian science of energy. Not only does the scientific origin of Hopkins' central poetic terms emphasize the Victorian identity of Hopkins' person and poetry, it also opens up a new valence of interpretation for Hopkins' work, namely the correspondence of Hopkins' philosophy of inscape with Rankine's concept of an object's self-distinctive stress.

Likewise, for readers interested in the history of science, this chapter advances a history of terms critical to modern physical science. Whether Rankine's vortex theory or his formulation of the laws of thermodynamics contributed to the making of new scientific knowledge, his linguistic innovations certainly did. His terms stress, strain, energy, actual energy, and potential energy, are standard in modern scientific writing, even if Rankine's initial intentions for these terms often differ from the way scientists currently define them.[18] While much has been said about Rankine's practical and theoretical work, and while several authors, Brown and Banfield among them, have noted his lexical additions to scientific language, none to my knowledge have traced the contemporary signification of stress and strain in an attempt to explicate the semantic field surrounding them in Victorian speech and culture.

2.1 Science and Social Uplift

William John Macquorn Rankine, in his 1858 *A Manual of Applied Mechanics,* discusses the evils of the heretofore unscientific practice of architecture in England:

> With respect to those works which, from unscientific design, give way during or immediately after their erection, I shall say little; for, with all their evils, they add to our experimental knowledge, and convey a lesson, though a costly one. But a class of structures fraught with much greater evils exists in great abundance throughout the country : — namely, those in which the faults of an unscientific design have been so far counteracted by massive strength, good materials, and careful workmanship, that a temporary stability has been produced, but which contain within themselves sources of weakness, obvious to a scientific examination only, that must inevitably cause their destruction within a limited number of years. (6)

Rankine's concern, repeatedly expressed, is to subject the "unscientific design" of British buildings to "scientific examination," and thus to build up a core of "experimental knowledge" to

[18] "Actual" energy has been replaced by "kinetic" energy thanks to the influence of William Thomson and P.G. Tait.

invigorate the flagging architectural profession. Rankine's ambitions for architecture were of a piece with his larger ambition to establish parity between the theoretical pursuits of the scientific and mathematical philosopher and the practical aims of the mechanic and engineer. As he announced to the Senate of the University of Glasgow upon his appointment to the Regius Chair of Civil Engineering (1855), the enlightenment of the Renaissance could be adduced to the proposition "that no [. . .] phenomenon, however familiar, is [. . .] beneath the attention of the philosopher; that [. . .] the labours of the artizan are full of instruction to the man of science; that the scientific study of practical mechanics is well worthy of the attention of the most accomplished mathematician" (*Manual* 3).

In so saying, Rankine adapted utilitarian rhetoric to defend his newly-won professorship as well as the burgeoning engineering profession. Yet in doing so, he not only exploited utilitarian rhetoric but articulated a general trend during the Victorian era for the practical professions to become more scientific and technical. As means to achieve the industrial virtues of efficiency and productivity, scientific methods of measurement and calculation were particularly prized by members of the practical occupations, and the practical pursuits consequently became increasingly technical during the industrial era. As the second occupant of the newly-established (1840) Chair of Civil Engineering and Mechanics at the University of Glasgow, Rankine himself owed his livelihood to this trend and considered his primary responsibility to promote and exhibit "the mutual communication of ideas between men of science and men of practice" (6). Likewise, the systems, schools, and centers of technical education that developed in Victorian Britain – from arrangements for working class and lower middle class wage-laborers like the Science and Art Department and the Midland Institute, to royally-endowed schools for the education of professional engineers like the School of Mines --

also contributed toward this trend to elevate the practical professions through scientific education.

Rankine was not alone in his insistence that engineering and the practical professions be established on an empirical basis. Rather, Rankine's academic appointment to teach as a scientific subject a profession that had traditionally been considered an artisan's trade represented the culmination of over a half century of reform. In 1797, another Scotsman, John Robison, had similarly called for scientific reform among Great Britain's practical professions:

> The man of science who visits our great manufactures is delighted with the ingenuity which he observes in every part, the innumerable inventions which come even from individual artisans, and the determined purpose of improvement and refinement which he sees in every workshop. But the philosopher is mortified to see this ardent spirit so cramped by ignorance of principle, and many of these original and brilliant thoughts obscured and clogged with needless and even hurtful additions, and a complication of machinery which checks improvement even by its appearance of ingenuity. There is nothing in which this want of scientific education, this ignorance of principle, is so frequently observed as in the injudicious proportion of the parts of machines and other mechanical structures; proportions and forms of parts in which the strength and position are no wise regulated by the strains to which they are exposed, and where repeated failures have been the only lessons. (Robison 1)

As well, in his aim to reduce the distinction between practical men and scientific philosophers, Rankine was preceded by yet another scientific academician who as professor at the Royal Military Academy was closely involved in training army engineers. In his 1806 *A Treatise on Mechanics: Theoretical, Practical, and Descriptive*, Olinthus Gregory "regretted"

> that a forbidding distance and awkward jealousy seem to subsist between the theorists and the practical men engaged in the cultivation of mechanics in this country: and it is a desire to shorten this distance, and to eradicate this jealousy, that has been a principal stimulant in the execution of the following performance. (v-vi)

In their desire to elevate the practical trades, particularly engineering, to the status of "philosophic" pursuits, Robison, Gregory, and Rankine participated in a nineteenth century trend in which emergently-scientific disciplines sought to achieve social recognition by furnishing society with a useful body of discipline-specific knowledge and work. Developing this knowledge, however, required communication between practitioners within the discipline, and this in turn required a precise and unambiguous language with which to communicate. Coterminous with the professionalization of the scientific disciplines, the development of a distinct register furnished engineering with a specialized vocabulary that would eventually enter the language of physical science generally.

Nevertheless, the vernacular origin of several terms within this vocabulary harks to the time before professionalization. Thus, the present register of physical science preserves its kinship with other disciplines within the Victorian milieu. A historical survey of the development of such terms as stress and strain shows not only the interpenetration of physics with art, architecture, and mechanics during the mid-nineteenth century, but also evidences the reciprocal relationship between science and general culture.

2.2 Stress and Strain: The Scientific Register in Development

Stress and strain are fundamental terms in the modern vocabulary of the physical sciences. As currently conceived, stress is a measure of force acting upon a given area, or, more simply, a measure of the force an object experiences. Strain, accordingly, measures an object's response to the force exerted on it, or the effect of the force upon the object, which often manifests as a change in shape. Modern physical sciences (primarily the disciplines of physics and engineering) recognize six types of strain – compression, tension, torsion, shear, bending, and fatigue.[19] Each of these instances of strain corresponds to stress, or to the effect of stress upon a material. Thus, for example, an object under compression shortens in response to two opposite forces compacting it, while an object under tension lengthens in response to two opposite forces stretching it. In addition to these macro-scale strains, physical and organic chemists investigate a number of atomic stresses and their molecular effects, including Van der Wals, torsional, and ring strain. Again, these strains constitute a molecule's response to stress, or, to reword, the effect of atomic stresses upon the structure of a molecule.

Consistently, then, the modern physical sciences treat stress and strain as reciprocal causes and effects.[20] Yet the present consistency of terms is a product with a history, the end

[19] Rankine himself was one of the pioneers of the study of metal fatigue. In the early 1840s, he studied stress cracks in locomotive axles, concluding that even iron and steel structures could be progressively weakened through stress cracking to the point of catastrophic failure. In a paper presented to the Institute of Civil Engineers, Rankine applied his research to explain the Versailles train crash of 1842, in which between 52 and 200 people died returning from the public celebrations honoring King Louis Philippe I. The flames resulting from the wreck were so intense that authorities were unable to assess the number of casualties. Rankine subsequently designed a process to manufacture stronger railway axles to resist stress cracking and fatigue. See Sendeckyj, "Early Railroad Accidents and the Origins of Research on the Fatigue of Metals."

[20] Since force can cause an object to change shape, and an object's change of shape can exert force, the causality of stress and strain is reversible, and strain can cause stress just as much as stress causes strain.

result of the process by which the verbal register of the physical sciences developed during the early and middle decades of the nineteenth century. As participants in this process, stress and strain lent structure to the emerging scientific language while simultaneously evolving along with it.

From the evidence of common speech, stress and strain were associated with words like "pressure" and "force" long before the nineteenth century and the evolution of the modern register of physical science. More precisely, stress and strain, in addition to being identified with force, functioned as particular aspects or manifestations of force that threatened the integrity of an object. As the *OED* notes, such an association informs the Earl of Surrey's 1547 *Poems* when, in his translation of Ecclesiastes 4, he observes that "the single twyned cordes may no such *stresse* indure/ As cables brayded thre fould may, together wrethed swer" (*OED* 5a, my emphasis). In this instance, *stresse* is a particular manifestation of force threatening to sever the "twyned cordes." Much the same usage features in Robert Venable's description of a fly rod in his 1662 *The Experienced Angler*: "for if you observe the slender part of the rod, if *strained*, shoots forth in length as if it were part of the line, so that the whole *stress* or strength of the fish is borne or sustained by the thicker part of the rod" (*OED* 5a, my emphasis). Again, in being *strained* or subject to the *stress* of the fish, the rod is threatened with breaking, and only the flexibility of the slender top and the greater strength of the thicker base allow the rod to preserve its form.

Similar usages prevail in nautical speech and writing. Captain Thomas James, in his account of his 1631-2 voyage in search of the Northwest Passage to the South Sea, recounts one stormy night where he and his crew "came to an Anker, and rid a good *stresse* all night" (387). Here, *stresse* indicates the force the ship exerts on the anchor and particularly the line, which must endure the mass and drift of the ship, or break. Likewise, W.H. Smyth's *Sailor's Word Book* defines the phrase to "set up rigging" as "to take in the slack of the shrouds, stays, and backstays, to bring the same *strain* as before, and thus secure the masts" (609).

As these nautical texts and Venable's *Experienced Angler* suggest, modern physics' customary pairing of stress and strain derives from ordinary speech just as much as its use of the individual terms themselves does. That this pairing was still common in the ordinary speech of nineteenth century speakers appears in the works of several poets. In Coventry Patmore's *The Angel in the House*, when the poetic speaker fantasizes of nuptial bliss with his future bride, his mind, "puzzled and fagg'd by stress and strain [. . .] made bliss more hard to bear than pain" ("Sarum Plain" 3.14). Likewise, Browning's *Aurora Leigh* complains of the "intolerable strain and stress" inherent in the poet's "sorrowful great gift" of representing outwardly "the thing he feels the inmost" (Book 5).

Patmore's and Browning's poems suggest the ease with which stress and strain have been metaphorically applied. While stress and strain denote physical force (particularly that jeopardizes the coherence of an object), they may also express emotional torsion (implicitly that jeopardizes one's psychological coherence). Likewise, since the eighteenth century, poets have appropriated stress to describe the emphasis a syllable is accorded within a line of poetry. The first such instance, from John Mason's 1749 *An Essay on the Power and Harmony of Prosaic Numbers*, asserts that 'The Accents [. . .] were designed very probably at first to regulate the Tone or Key of the Voice, not the Stress or Force of it' (*OED*, stress n. I.9). Mason adapts the word stress in reference to syllabic emphasis, but the fact that he pairs "Stress" with "Force" indicates that he applies the conventional, physical meaning of the term metaphorically. At base, stress and strain address physical relations of force, and their metaphorical usages extend from this originary meaning.

These examples indicate that, before and during the nineteenth century, stress and strain were commonly used in ordinary speech to describe physical force (and, by metaphorical extension, psychological pressure and syllabic stress). Not surprisingly, then, nineteenth century writers who observed physical forces at work in Nature frequently invoked these terms. Yet as professional discourses specialized, the terms stress and strain likewise accrued specialized significance in the technical disciplines that employed them.

2.2.1 Strain in Chemical Literature

Given their ubiquity in ordinary speech, the terms stress and strain suggested themselves readily to nineteenth century writers who investigated the nature and strength of molecular bonds, researched the behavior of gases subjected to variations of pressure and temperature, or tested the resistance of architectural materials to a load. Pertaining to the first of these investigations, as the accumulating mass of chemical literature fostered a rapid extension of theory, scientific writers struggled to find language fit to express new research. Stress and strain readily crossed from ordinary language to professional writing, as scientists' literary and lexical struggles induced them to repurpose familiar terms to newly-emerging theoretical contexts. Such rapid linguistic innovation challenged communication, however, and many of the foremost chemical authors express concern to chasten scientific language to represent experimental findings clearly and unambiguously. These concerns prompted, on the one hand, a proliferation of new terms that furnished chemists with a tightly-defined professional register and, on the other hand, a suspicion of terms borrowed directly from common speech.

J.F.W. Herschel's *Encyclopedia Metropolitana* treatise "Light" (1830) includes not only an early discussion of molecular strain, but also manifests a self-conscious interest in the technical assumption of common words. One of Herschel's primary concerns is to clarify the developing terminology of photometric science. Thus, in the opening pages of his article, he offers the following definitions:

> Definition. The apparent superficial magnitude, or the apparent magnitude of any object, is a portion of a spherical surface described about the eye as a centre, with a radius equal to I, and bounded by an outline being the intersection of this spherical surface with a conoidal surface, having the object for its base and the eye for its vertex. [. . .]
>
> Definition. The real intrinsic brightness of a luminous object is the intensity of the light of each physical point in its surface, or the numerical measure of the degree in which such a point (of given magnitude) would illuminate a given object at a given distance, referred to some standard degree of illumination as a unit. [. . .]
>
> Definition. The apparent intrinsic brightness of any object, or luminary, is the degree of illumination of its image or picture at the bottom of the eye. [. . .]
>
> Definition. The absolute light of a luminary is the sum of the areas of its elementary portions, each multiplied by its own intrinsic brightness. (346)

After establishing the meaning of these technical terms, Herschel then descants on their relationships to common speech. In so doing, Herschel is particularly concerned with the danger of confusing technical terms that descend from a single common word, as in his discussion of the "brightness" of objects:

> In common language, when we speak of the brightness of an object of considerable size, we often mean its *apparent intrinsic brightness*. When, however, the object has no sensible size, as a star, we always mean its *apparent light*, (or, as it might be termed, its *apparent absolute brightness*,) because as we cannot distinguish such an object into parts, we can only be affected by its total light indiscriminately. The same holds good with all small objects which require attention to distinguish them into parts. Optical writers have occasionally fallen into much confusion for want of attending to these distinctions. (346, emphasis original to text)

Despite Herschel's self-conscious concern to segregate common from technical usage, his use of strain seems casual. In Herschel's careful disaggregation of the technical senses of "brightness," his scientific language subdivides common usage, and assigns each of the multiple significations of the common word to a tightly-defined, carefully circumscribed scientific term. With strain, however, Herschel uses the same term in a variety of senses, some indisputably technical but others less certainly so. In his essay on "Sound," for example (also 1830), Herschel comments upon the "well authenticated feat performed by persons of clear and powerful voice, to break a drinking-glass by singing its proper fundamental note close to it" (783). In his explanation of this common phenomenon, Herschel proposes that "the excursions of [the glass'] molecules in the vibrations into which they are thrown [are] so great as to strain them beyond the limits of their cohesion" (783). While Herschel applies strain to molecular behavior here, and thus supplies a scientifically-informed explanation of a common phenomenon, he means the same thing that a speaker discussing the strain on a fishing pole or length of twined cords intends – a force or pressure exerted against an object in opposition to its internal strength. Thus, Herschel speaks of molecules rupturing and breaking apart from one another in much the same way as the fibers of a fish pole or rope might.[21] In this instance, Herschel's application of strain to molecular behavior lends the term empirical cachet, but without the specialized context supplied by Herschel's discussion of molecules, his meaning would be identical to everyday usages of the word.

In Herschel's article "Light," he again represents the relationship between common experience and speech, and scientific knowledge and language. In this article, Herschel employs the concept of strain to explain a number of phenomena, ranging from the deformation of crystals to the ability of unevenly-heated glass to polarize light. Both of these phenomena result from the expansion of matter due to heat, or the retraction of it due to cold. Again, however, Herschel points out the common-place equivalent of these phenomena, the capacity of glass to shatter when unevenly heated. Since molecular bonds lock the hotter particles, expanding, in place with the cooler particles, the "immediate effect of an increase or diminution of temperature in any one point of a piece of glass, is to produce a mechanical strain on all the surrounding part" (564). Given sufficient difference of temperature, the consequent strain is "capable of breaking asunder the thickest pieces of glass; an effect with which every one is familiar" (564).

In "Sound" and "Light," then, Herschel repeatedly compares common experience and scientific knowledge, as well common speech and scientific language. Granted, Herschel undoubtedly does so to help uninitiated readers understand the scientific terms and principles he discusses. But additionally, Herschel explains scientific knowledge as rising from but ultimately above common knowledge, being able consequently to explain the commonly perceived but

[21] And with good reason, given that an object's rupturing necessarily entails the separation of its constituent molecules. My point here is not that Herschel misapplied the term, but that strain's conventional meaning readily accommodated new scientific developments.

imperfectly understood phenomena of the world. Likewise, Herschel depicts scientific language as originating from the welter of common speech, but being systematized with logical rigor and precision. Despite these intentions, however, and in contrast to the way he treats other specialized terms, Herschel adapts strain to scientific speech without delimiting or defining its denotation in any special sense.

But while Herschel seems comfortable with strain's dual citizenship in both popular and technical speech, other writers treated the term with more suspicion. Thus, although its facility to express relations of force recommended it to scientific authors, its capacity to retain its conventional meaning even as it extended its sphere of signification to the developing register of physical chemistry rendered it suspect. Strain's ubiquitous applicability – and the necessity to develop an accurate and unambiguous mode of specialized speech -- may have influenced Michael Faraday to eschew the term in favor of its near-synonym tension.

Like Herschel, Faraday apprehended the linguistic challenges posed by the proliferation of chemical research and writing, and his concern to develop a precise scientific lexicon appears in his numerous verbal coinages. When, for example, Faraday proposed electrochemical attraction as the prerogative of an electrical current and not, as was then commonly believed, the work of the current's poles, his refinement of electrochemical theory prompted refinement of electrochemical language:

> The theory which I believe to be a true expression of the facts of electro-chemical decomposition [. . .] is so much at variance with those previously advanced, that I find the greatest difficulty in stating results, as I think, correctly, whilst limited to the use of terms which are current with a certain accepted meaning [. . . .] To avoid, therefore, confusion and circumlocution, and for the sake of greater

> precision of expression than I can otherwise obtain [. . .] I purpose henceforward using certain other terms, which I will now define. ("On Electro-Chemical Decomposition, Continued," 111-2)

To clarify his argument, Faraday replaced the term "pole" with the term "electrode," and dubbed the negative pole the "cathode" and the positive pole the "anode." Likewise, substances that are susceptible to decomposition under the influence of an electrical current he called "electrolytes," and the individual particles released during the electrolyte's decomposition he termed "ions." Since ions are mobile, borne along by the current to either the anode or cathode, Faraday likewise subdivided "ions" into "cations" and "anions." Those that that congregate at the anode he named "anions," and their counterparts that travel to the cathode he labelled "cations."

Strain's protean applicability, taken together with Faraday's persistent concern for verbal clarity and semantic precision, potentially explains Faraday's typical avoidance of strain in favor of tension. While tension peppers the pages of Faraday's writing, strain occurs rarely. By my count, Faraday uses the term strain, along with its derivatives restrain, restraint, constrain, and constraint, eight times in his 469-page *Experimental Researches in Chemistry and Physics*. By contrast, tension alone, to say nothing of its derivatives, occurs in some instances three or four times on a single page.

A possible explanation for Faraday's apparent reticence regarding strain appears in the rare instances when he does employ it. In his "On the Liquifaction and Solidification of Bodies generally existing as Gases," Faraday describes the construction of one of his experimental apparatuses. It is a complex affair of tubes and pumps, but Faraday contrives to arrange the device so that one tube "could be raised and lowered vertically, without any strain upon [its] connexions," with the other tubes (*Chemistry*, 101). While the term appears in Faraday's description of the construction of a scientific apparatus, the function of the term itself is in no way technical – the machine that Faraday builds measures the expansion of gases in response to temperature and pressure, but what Faraday describes here is merely the arrangement of the tubes themselves, not the behavior of gases or molecules of matter. While an engineer might be interested in measuring quantitatively the strain exerted by one part of a structure on another, such is not Faraday's intention here – Faraday means to measure and quantify the behavior of gases, not the behavior of the parts of his machine. Faraday's usage of the term here is then casual, neither theoretical nor quantitative.

Apparently, Faraday's suspicion of strain resulted from its range of expression, and its fungibility disqualified it from inclusion within the discipline-specific language that Faraday helped to create. When Faraday does discuss the behavior of gases and molecules, as well as the forces of electricity, magnetism, and light, he characteristically avoids strain in favor of the older, Enlightenment sense of tension. In modern scientific language, tension is a subset or particular variety of strain (a strain that stretches or elongates). But in Enlightenment philosophy, tension applied to any condition that prompted an elastic response from a substance. In rough terms, the Enlightenment sense of tension and the modern sense of strain are synonyms. For example, in his *Experimental Researches in Chemistry and Physics*, Faraday repeatedly describes gases as "having tension" when they exert pressure against a container, or even, as in the case of atmospheric gases, when they resist or counter the force of gravitational attraction. In modern scientific language, confinement of a gas within a container or the effect of gravity upon a gas would be termed compression, the exact opposite of tension. But since Faraday's Enlightenment sense of tension is synonymous with the modern sense of strain, compression for

Faraday is a subset of tension instead of its opposite. In essence, Faraday's term tension applies to any circumstance in which an object's elasticity is evoked.[22]

That tension and strain are precisely synonymous for Faraday appears in several fortunate parallels from Faraday's oeuvre. In his popular children's lecture *On the Various Forces of Nature*, Faraday explains how molecular "strain" within a piece of glass alters its refraction of polarized light (71).[23] In a parallel passage from *Experimental Researches in Chemistry and Physics*, Faraday explains a similar phenomenon in which "an irregular tension" within an optic lens corrupts its refractive uniformity (237). The fact that both strain and tension occasion the same effect within a piece of glass suggests that Faraday considers the terms as expressing one and the same phenomenon.

When Faraday does resort to "strain" (other than the aforementioned children's lecture – see footnote 11), he attempts to delimit its meaning and function through grammatical prefixes and suffixes. Thus, "restrain," "restraint," "constrain," and "constraint" figure much more frequently in Faraday's writings than strain itself does.[24] Given Faraday's characteristic

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[22] See also Faraday's *Experimental Researches in Electricity*, where Faraday repeatedly describes electrical currents as building up "tension" when their circuits are impeded by an insulator. In these instances, tension evidently means "pressure" or "compression." The imagery is of a compressible fluid building up pressure until at last its pent force enables it to pierce its way through the obstacle that impedes it.

[23] This children's lecture is one of the very rare instances when Faraday uses strain to describe molecular force and behavior. Even in the infrequent instances when Faraday refers to strain instead of tension, he typically attempts to circumscribe strain's wide applicability by adding suffixes and prefixes (see below). In this instance when Faraday does neither, his audience should be considered. Faraday presented this lecture to an audience of adolescents, and may well have selected strain in this instance for the very reason he avoided it in others – its ability to overlap common and scientific speech.

[24] This is not without difficulty, either, since the derivatives of strain carry metaphoric resonances of their own that further perplex verbal precision. For example, Faraday in one passage may use "constrain" to represent physical force exerted on an object, and yet in another passage use the same word to express a sense of moral obligation exerted upon a human being. Cf. *Experimental Researches in Chemistry and Physics*, pgs. 436 and 475: in the first instance,

grammatical derivations of strain, when William Thomson as a young man famously wrote to enquire of his scientific hero of the then-hypothetical relationship between magnetism and light, the young Thomson demonstrated his intimacy with Faraday's thought both conceptually and rhetorically. In addition to citing Faraday's coinage of the "dielectric," Thomson also reproduced Faraday's typical use of "constraint" for strain:

> A third question which I think has never been investigated is relative to the action of a transparent dielectric on polarized light. Thus it is known that a very well defined action, analogous to that of a transparent crystal, is produced upon polarized light, when transmitted through glass in any ordinary state of violent constraint. If the *constraint*, which may be elevated to the point of breaking the glass, be produced by electricity, it seems probable that a similar action might be observed. (Aug 6, 1845, my emphasis)

But even this effort does not produce the terminological consistency that Faraday expected of scientific writing. Faraday's grammatical permutations of strain carry metaphoric resonances of their own that perplex verbal precision. For example, at one point in his 1857 essay "On the Experimental Relations of Gold (and other Metals) to Light*,"* Faraday describes the ability of thin gold foil to polarize the small quantity of light that passes through it. This polarization, Faraday remarks, "does not seem due to any constrained condition of the beaten gold," or does not result from strain induced between the molecules by the hammering process, but is also present in "annealed leaf-gold," "deposits of gold particles," and "other uncrystallized transparent substances" (436). Yet while "constrain" here refers to tension or strain between molecules of gold, Faraday more frequently applies the word to express moral obligation. Thus,

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the gold is "constrained" by mechanical force (being beaten), while in the second, the scientific observer is constrained through habitual mental and moral discipline.

in an 1855 essay "On Mental Education," Faraday warns against "the temptation which urges us to seek for such evidence and appearance as are in favor of our desires," and urges readers to "[practice] wholesome self-abnegation" (475). Yet such self-abnegation is impossible, Faraday claims, "for anyone who has not been constrained, by the course of his occupation and thoughts, to a habit of continual self-correction" (475). Granted, both the metal under the hammer and the mettle under moral discipline are alike in that they are forced and strained against their natural inclinations. But the very metaphoric nature of Faraday's usage prohibits his sense of constrain from achieving the singular denotation that he expected of scientific terms.[25] Try as he might to control the meaning of his words, Faraday's derivations of strain persistently lapse from scientific precision and revert to the broader significations of ordinary speech.

Faraday's difficulties with strain instance the struggles other scientific authors had with it as well. In turning in the next section to the engineering sciences, we will survey the various permutations the term assumed in the mechanical and physical sciences as authors attempted to pare its meaning to a single and stable signification. W. J. M. Rankine at last fixed its meaning in 1850 paper, "Laws of the Elasticity of Solid Bodies," drawing from chemistry as well as engineering and physics to assign the word a stable definition. Rankine's proposed definition was seconded by Thomson, and was subsequently adopted by the scientific community at large. Ironically, however, in at last articulating strain definitively as a scientific term distinct from the multiplex associations of common usage, Rankine added yet another association. In conjunction with Rankine's companion term stress, this scientific association of strain would enrich common

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[25] For other moralizing instances of *constrain* in Faraday's oeuvre, see *Experimental Researches in Chemistry and Physics*, 136, as well as *Experimental Researches in Electricity*, 232, 233, and 313. Much the same may be said of constraint, restrain, and restraint – each of these figure in Faraday's writings as both an expression of molecular tension operative upon particles as well as a moral force operative upon individuals.

culture with a mechanical ontology, the most lasting effects of which would take shape in the poetry of Gerard Manley Hopkins.

2.2.2 Strain and Strength in Engineering Literature

A similar effort to chasten the semantic field of strain appears in engineering and architectural literature. Although architecture was an established discipline long before the nineteenth century, the impetus during the nineteenth century to establish the professions on an empirical basis revitalized architecture and bred a number of technical architectural treatises. In "Strength," an entry written for the 1797 *Encyclopaedia Britannica*, John Robison, Professor of Natural Philosophy at the University of Edinburgh, defines strain as a particular manifestation of force that potentially threatens an object's integrity. Thus,

> A piece of solid matter is exposed to four kinds of strain, pretty different in the manner of their operation. 1. It may be torn asunder, as in the case of ropes, stretchers, king-posts, tye-beams, &c. 2. It may be crushed, as in the case of pillars, posts, and truss-beams. 3. It may be broken across, as happens to a joist or lever of any kind. 4. It may be wrenched or twisted, as in the case of the axle of a wheel, the nail of a press, &c. (8)

In so defining strain, Robison juxtaposes it against cohesion, the "connecting force" that holds the object's component parts together (2). Furthermore, Robison explains, when the object experiences a strain, the cohesion between its particles is "excited" or "brought into action" as strength (2). Robison's usage may be surprising to modern readers, who regard strength as either a quality or quantity, but Robison emphatically expresses strength as an actual and active force:

> It is this action which is what we call the strength of that part [. . . .] Thus when we observe a rope prevent a body from falling, we infer a moving force inherent

> in the rope with as much confidence as when we observe it drag the body along the ground. The immediate action of this force is undoubtedly exerted between the immediately adjoining parts of the rope. The immediate effect is the keeping the particles of the rope together. They ought to separate by any external force drawing the ends of the rope contrary wise; and we ascribe their not doing so to a *mechanical force really opposing* this external force" (2, my emphasis).

Strength, in Robison's usage, is not merely a measure of cohesion. More than a quantity ("How strong?" "How much strength?"), strength exists as an actual force. Just as the external force exists which subjects the object to pressure, so strength exists as an internal force by which the object resists pressure. In fine, strength is the force of self-coherence an object exerts in response to an external strain. Phrased alternately, when an object experiences strain, it exerts strength to neutralize the strain and to preserve its integral form. Given that strength is an actualized expression of the cohesion between an object's particles, and given that this cohesion depends on the organization and structure of the particles themselves, strength can further be defined as a force of self-coherence expressive of an object's material composition or identity.

Subsequently, however, in a curious shift, Robison sublates the force jeopardizing the object with the force sustaining it, treating both as opposite facets of a single identity. As Robison describes, "We must have some notion of that intermedium, by the intervention of which an external force applied to one part of a lever, joist, or pillar, occasions a strain on a distant part. This can be nothing but the cohesion between the parts" (2). In other words, strain propagates through the extent of an object only if the "cohesion between the [object's] parts" is sufficient to endure the strain without breaking. If the object's cohesion were to fail and the object were to break, then strain would no longer stem from one part of the object to the next.

For this reason, Robison perceives external strain not so much as opposed to an object's self-distinctive strength but rather "exciting" it or calling it from a dormant state to a state of active expression (2). In effect, strain simultaneously exerts pressure without and excites strength within, and up to the limit of the object's cohesion, stress and strength are identical. As Robison explains, "thus it is the same force differently viewed, that constitutes both the strain and the strength" of an object (2).

To summarize Robison's definitions, strain refers to an external force that threatens to overpower the cohesion between an object's parts. At the same time that strain threatens the object's particular cohesion, however, it calls forth from the object an expression of that cohesion in the form of strength. Strength then is a real – not a potential – force, and is deployed in exact response to an external strain, up to the limit of the object's cohesion. Much as strain exerts force without to destroy the object, so the object exerts force within to preserve itself. Strength then is an active force of self-preservation, a direct expression of the object's proper molecular or particular cohesion. In essence, strength stems from and expresses the particular structure or identity of the object.

Such distinctiveness of definition likewise characterizes Peter Barlow's employment of strain and strength in two of his influential treatises, his *Essay on the Strength and Stress of Timber*, first published in 1817, and his *Encyclopaedia Metropolitana* article "Mechanics."[26] In what would now be considered plagiarism, Barlow, in the opening pages of his *Essay*, embellishes Robison's four-fold definition of strain, interlacing his analysis with short quotations

[26] The versions I have been able to locate are later editions (*Essay*) or reprints ("Mechanics"). At the time of Barlow's writing, stress and strain were considered to be precisely synonymous. This is better seen in Olinthus Gregory's *Treatise* (see below). Rankine would segregate these terms, treating *stress* as a synonym for *strength* instead of *strain* (see below as well).

culled directly from his predecessor's essay on "Strength" (compare italicized phrases below with Robison's words quoted above):

> Four distinct cases or strains may be stated as follow: 1. A body *may be torn asunder* by a stretching force applied in the direction of its fibres, *as in the case of ropes, stretchers, king-posts, tye-beams, &c.* 2. *It may be broken across* by a transverse strain, or by a force acting either perpendicularly or obliquely to its length, as in the case of *levers, joists,* &c. 3. A beam or bar *may* also *be crushed* by a pressure exerted in the direction of its length, *as in the case of pillars, posts, and truss-beams*. 4. *It may be twisted or wrenched* by a force acting in a perpendicular direction, at the extremity of a lever or otherwise, *as in the case of the axle of a wheel, the nail of a press, &c.*[27] (1-2, emphasis mine)

Inherent in Robison's and Barlow's definitions of strain is a desire to treat the meaning of the term precisely and consistently. Accordingly, in Barlow's later article for the *Encyclopaedia Metropolitana*, he avoids using the terms strain and strength in his initial exposition of the laws of force and his subsequent calculations of the force exerted and the work performed by simple machines. This is consistent with the conception of these terms that he derives from Robison: in the first part of this article, Barlow does not investigate the strain a machine can endure before failing but rather the force it can exert or the work it can perform.[28] Accordingly, Barlow's

[27] In Barlow's defense, past authors should not be held responsible for conventions of quotation and citation adopted after their time. Nor does Barlow shirk acknowledging his debt to Robison, whom he frequently and prominently acknowledges in this *Essay*, albeit not in the passage quoted above. In pointing out that Barlow's adoption of Robison's phrases would now be considered plagiarism, I do not mean to accuse Barlow of dishonesty. Rather, I merely mean to show the similarities in their conception of strain, given that Barlow adopts Robison's definitions as his own.

[28] Two exceptions occur in this section. In the first, on page 51, Barlow briefly mentions the requisite "strength" of a machine's parts in order that "they shall not break under the weight they

concern is not with the likelihood of the machine catastrophically shattering or exploding but with the amount of work it can produce in its normal operation. Since Barlow and Robison consider strain and strength as alternate modes of an object's intrinsic capacity of cohesion, Barlow in the first part of his article uses the generic word "force" instead of the specific term "strain."

However, when in the same article Barlow turns from machines to architecture, he likewise turns from investigating force exerted to force endured. In doing so, Barlow shifts attention from investigating force's ability to perform useful work to its propensity to deform or destroy – in a word, to exert what Robison meant by "strain." Tellingly, Barlow introduces strain precisely at the point his investigation turns to architecture, and he systematically employs it throughout his subsequent research of the architectural strength of various "solid bodies" or building materials such as timber beams, stone blocks, and iron bars. Barlow's restricted use of the term causes it to appear and disappear abruptly in his text. In the 54 pages before Barlow first proposes to "[compute] the relative strains upon solid bodies" (i.e., building materials), the term does not appear even a single time (54). Likewise, in the nearly 90 pages following his investigation of the strength of architectural materials, Barlow again suspends use of the term, with the exceptions of calculating the strain a bank of earth imposes on a revetment and remarking on the "disagreeable strain" felt when "we strike a smart blow with a stick" and "feel a painful wrench in the hand" (139). Yet these exceptions prove the rule: In the first instance, Barlow's investigation of a revetment's strength to endure the strain of the bank is closely akin to

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are intended to counteract." Here, Barlow's use of "strength" corresponds with his shift in focus from the machine's capacity to exert force to its capacity to endure strain. This exception further evidences Barlow's consciously consistent use of strength and strain. The second exception does not, however. In this second instance, Barlow remarks on the force generated by "a man of medium strength, striking with a maul weighing 18 lbs" (52). Here, Barlow uses the term "strength" in the common sense.

his inquiry into the strength of architectural materials to endure a load. In the second instance, Barlow's description of the "painful wrench" felt in the hand recalls Robison's 4th description of material under strain -- "it may be wrenched or twisted, as in the case of the axle of a wheel, the nail of a press, &c." (Robison 8).

The distinctive conventions of Robison and Barlow's nomenclature become more apparent given Newton's third law, of equal and opposite reaction. Robison and Barlow concur that strain opposes strength, not as a measure of any force exerted by the object (as in a machine at work) but as a measure of the force it endures. Logically, however, an object endures any force it exerts. Thus, when a machine exerts pressure against an object, it exerts pressure against its members and parts as well. But the application of the term strain reflects a human observer's perspective, not physical reality. When Barlow concerns himself with the work a machine can produce, and not the pressures it experiences, he consequently eschews the terms strength and strain. From an objective standpoint, however -- one that does not entertain Barlow's perspective or purpose in observing -- when a machine exerts force, it experiences pressure.

Similarly, Robison and Barlow express strength as an active force preserving, and expressing, the object's internal composition. If an object's strength consists in its ability to resist strain and to preserve its integral form, then strength is a direct expression of an object's elasticity or cohesion. Given that strength stems from the molecular or "particular" composition of an object -- or from the bonds between those molecules that give the object its being -- then strength is an expression of the essential composition of the object.

Robison's and Barlow's distinctive usage and application of strain explains the term's appearance in architectural writing later in the century. Joseph Gwilt, in his 1842 *An Encyclopedia of Architecture*, treats strain as a discipline-specific term, defining it in his technical glossary as "the force exerted on any material tending to disarrange or destroy the cohesion of its component parts" (1038). In this definition, Gwilt's opposition of strain to the "cohesion" of "component parts" preserves an echo of Robison.

Regarding stress, Olinthus Gregory's 1806 *A Treatise of Mechanics, Theoretical, Practical, and Descriptive* clarifies that stress during the early nineteenth century was used "indiscriminately" as a synonym for strain (105). Besides clarifying the relationship of strain and stress, Gregory's work also attests the normativity of Robison's definitions of strength and strain. To quote the passage in full,

> 168. DEF. Strength, and Stress or Strain, are terms, the former of which [strength] is used to denote the force or power with which any mass or body resists a breach or change in its state, which a pressure or stroke upon it has a tendency to produce; and the latter [stress *and* strain] are used indiscriminately to express the force which is excited in any such mass and tending to break it. Thus, every part of a pillar is equally strained by the load which it supports. Hence, it is evident that we cannot make any structure fit for its purpose, unless the strength in every part be at least equal to the stress laid on, or the strain excited in that part: and hence the necessity of an acquaintance with the nature of the resistance of bodies, so that there shall be neither a surplus nor a deficiency of materials in any machine. (105)

As in Barlow's and Gwilt's works, Gregory's *Treatise* draws directly from Robison's definitions of *strength* and *strain*. With Robison, Gregory defines strength as an actual "force or power with which any mass [. . .] resists a breach or change in its state." Thus, strength is not merely an index or measure of cohesion, but is an actual "force or power" in its own right.

Moreover, Gregory borrows Robison's striking description of strain being "excited" within the object, even if, in doing so, Gregory signals his ambivalence about Robison's rapprochement of strength and strain. In Robison's essay "Strength," although he initially deploys strain and strength as opposed moments, the fact that strain "excites" strength in an object ultimately sublates their negation, and "thus it is the same force differently viewed, that constitutes both the strain and the strength of an object" (Robison 2).[29] In the passage quoted above, however, Gregory maintains the opposition between strain and strength. Even though strain/stress acts simultaneously upon the object and within it – "stress" is "laid on" the object while "strain" is "excited in" it -- Gregory avoids reconciling strain/stress to strength. Whether laid on or excited within the object, stress/strain continues to oppose strength. Thus, "the strength in every part [must] be at least equal to the stress laid on, or the strain excited in that part" (105). Consequently, Gregory sees two forces warring within an object's members: strength, a force of cohesion, and strain/stress, a force of disruption. All the same, Gregory's departure from Robison demonstrates the latter's influence, and in echoing Robison's characteristic description of strain exerting force from without yet nevertheless being "excited" within (albeit *not* as strength but in opposition to it), Gregory revisits Robison's terminology and conception of an object under strain.[30]

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[29] In casting Robison's ideas in Hegelian terminology, I do not mean to imply that Robison ever heard of Hegel or was influenced by his ideas. Instead, Hegel's terms offer a convenient means to explain Robison's negative moments of strain and stress. The fact that Hegel derived his critical term "moment" from his study of mechanics excuses -- at least partially, I hope -- my application of his terms to Robison.

[30] A web of influence links the works of Robison, Gregory, and Barlow. Gregory's and Barlow's debt to Robison has been discussed above. Likewise, Barlow borrows the title of his *An Essay on the Strength and Stress of Timber* from a line in the introduction to Gregory's *Treatise*, in which Gregory proposes to "treat of [. . .] the strength and stress of timber and other materials" (Gregory viii).

Beyond Gregory, Barlow, Gwilt, and Parker, Robison's ideas of strain and strength extended further into the nineteenth century to a Scottish railroad engineer who would eventually win the recently endowed Regius Chair of Civil Engineering at the University of Glasgow. William John Macquorn Rankine would finally fix the definition of strain, and would postulate an important, but ultimately disavowed, definition of stress. Although Rankine's definitions would alter Robison's terminology, Robison's concept of the reciprocity between outer and inner forces -- particularly his concept of an active, inner force expressive of the structural identity and particular cohesion of the object – would be especially important for Rankine's later definitions of stress and strain.[31]

2.3 Stress, Strain, and Enegy Science

As scientific investigations proliferated during the nineteenth century, not only did scientific enterprise become increasingly demarcated by disciplinary boundaries, but the established crafts became increasingly technical. In this multiplicity of technical discourse, technical writers repurposed existing words -- when available -- to suit the particular needs of their developing disciplines. Stress' and strain's status as technical terms within the cognate but diverging registers of architecture, physics, and chemistry instances the broad applicability of single terms to a spectrum of technical interests, or shows how familiar words accrue new applications within specialized professional registers.

[31] Essentially, Rankine's "stress" is identical to Robison's "strength" – the internal force of vital identity. Robison's "strain" is Rankine's "external pressure" – the external force threatening the object's structural integrity. As for Rankine's strain, Rankine means a change in shape, not the force itself that causes the change in shape. All the same, while Robison conceived of strain as a force, not a change in shape, he did define the various strains by their directions of stretching, compressing, twisting, and shearing. Since the directional forces determine the resulting shape of the object, Rankine's definition of strain as a change in shape are analogous to Robison's definition of strain as a direction of force.

Yet when W. J. M. Rankine redefined *stress* and *strain*, he did not merely extend the terms' application but altered their denotation. Rankine's linguistic innovation of *stress* particularly, though promptly squelched by more authoritative voices who restored it to its customary meaning, nevertheless resurfaced periodically in future physicists' writing. As well, a startling similarity between Rankine's definitions of the terms and Hopkins' use of them conjoins Rankine's vitalist physics with Hopkins' philosophy and poetics of inscape.

Like Faraday, Rankine was an inveterate innovator of scientific terminology,[32] one whose encyclopedic mastery of the literary corpus of the physical sciences made him sensitive not only to a term's customary signification but also to the way an inapposite or improperly defined term could mislead scientific judgment. In a paper he read before the 1850 assembly of the British Association for the Advancement of Science (hereafter the BAAS), Rankine prefaces his new definition of strain by pointing out the imprecision of the term's accepted signification in common speech. In Rankine's words,

> It is desirable that some single word should be assigned to denote the state of the particles of a body when displaced from their natural relative positions. Although the word strain is used in ordinary language indiscriminately to denote relative molecular displacement, and the force by which it is produced, yet it appears to me that it is well calculated to supply this want. I shall therefore use it, throughout this paper, in the restricted sense of relative displacement of particles, whether consisting in dilatation, condensation, or distortion; while under the term pressure I shall include every kind of force which acts between elastic bodies, or the parts

[32] One only has to read a page at random from Rankine's *A Manual of Applied Mechanics* to witness his near-mania to name and to number. Readers will most likely be familiar with several of Rankine's other coinages, including "potential energy," "actual energy" (later changed to "kinetic energy"), and, arguably, "energy" itself as understood by modern physicists.

> of an elastic body, as the cause or effect of a state of strain, whether that force is tensile, compressive, or distorting. (*Misc.* 68)

To condense Rankine's critique, the meaning of strain in "ordinary speech" is "indiscriminately" freighted with multiple senses, signifying both the force that causes a body's shape to change and the actual change of shape itself. In the interests of greater precision, Rankine proposes to divide or "restrict" the semantic domain of strain, referring to the force exerted upon molecules as pressure, and the change of shape thereby induced as strain.[33] Although Rankine's redeployment of strain amounts only to a reduction of its ordinary meaning and is in no way as radical as his subsequent treatment of stress (see below), it nevertheless accomplishes for the term what had eluded Herschel and Faraday: paring the term's complex signification in ordinary speech to a stable, single meaning devoid of uncertainty or ancillary interpretation. In so chastening the signification of strain, Rankine enabled scientific speakers to express, succinctly and unambiguously, the relationship between force and figure, or between an object's shape and the forces at play upon the object.[34]

In describing an object's change of shape as "relative molecular displacement," Rankine overtly tailors his chastened sense of strain to the technical discourses of chemistry and physics. But consistently in his 1850 BAAS paper, Rankine has the practical professions of architecture and engineering squarely in view. Rankine's practical emphasis appears from his first page, where he claims that the "most important application" of the "science of the elasticity of solid

[33] It should be remembered that causality between *pressure* and *strain* may also be reversed, as Rankine observes in the passage quoted above.
[34] Rankine's curtailed definition of *strain* is still observed in the physical sciences of engineering, mechanics, physics, and chemistry. In the last, it has given rise to the expressions "molecular strain" and "strain energy," referring to the energy stored within a molecule as a result of its constituent elements being forced out of their normal shape or position. Ring, Van der Waals, and torsional strain are types of molecular strain.

bodies" is "the determination of the strength of [architectural] structures" (67). Likewise, he repeatedly illustrates abstruse definitions and technical points with examples drawn from carpentry and construction. Thus, to clarify his term transverse elasticity, Rankine first provides a more common synonym, rigidity, and then explains "When a beam, or any other portion of a solid structure, takes a set (or undergoes permanent alteration of figure), it is the rigidity which has been overstrained and gives way" (78-9). Such concern to connect the philosophical and the practical is consonant with his later assertion of the parity of the artisan with the philosopher, and also with the trajectory of his future career as an academic engineer.

Rankine's redefinition of stress followed as much from his intellectual identity as a practical philosopher or engineering physicist as from his curtailed denotation of strain. In his 1850 definition of pressure versus strain, he distinguished only between force and molecular displacement, or force and change of shape. As Rankine explains, causation reciprocates between pressure and strain, and changes in an object's shape may exert force as much as force may cause an object to change shape. Thus, as Rankine proposes, "under the term pressure I shall include every kind of force which acts between elastic bodies, or the parts of an elastic body, as the cause or effect of a state of strain" (68).

Yet although Rankine has subsumed all force as pressure, whether caused or causal of molecular displacement, he subsequently segregates pressure in two categories. The first category includes external pressure, or any force that strains an object out of shape and potentially destroys its form. The second category of pressure refers to a structure's internal strength or molecular coherence and "consists in a tendency of the body to recover its natural state" after being strained (74).

At length, Rankine adapted stress to denote the second form of pressure resident in the molecular composition of an object that enables the object to resist external pressure and to preserve its distinctive form and shape. Though Rankine's term differs from Robison, Gregory, and Barlow's, his definition of stress accurately reproduces their description of strength. As Rankine explains, stress is an active force depending on the molecular composition of an object. As an active force, it intensifies directly with strain and external pressure. Rankine defines the triple relationship in his 1855 paper, "On Axes of Elasticity and Crystalline Forms":

> In this paper, the word *strain* will be used to denote the change of volume and figure constituting the deviation of a molecule of a solid from that condition which it preserves when free from the action of external forces; and the word *stress* will be used to denote the force, or combination of forces, which such a molecule exerts in tending to recover its free condition, and which, for a state of equilibrium, is equal and opposite to the combination of external forces applied to it. (*Misc.* 120)

As such – and reminiscent once more of Robison and Barlow -- stress in its variable guise depends on pressure and strain and is called forth by them, functioning as an active force called into being within the object that balances or equilibrates the external forces exerted upon it. Up to the limit of the object's elasticity, the more pressure exerted against the object, the more stress the object musters in opposition from within. In so saying, the variable activity of stress necessarily depends on a stable substratum. While stress may be evoked by external force, the evocation manifests an essential quality of the substance, namely its elasticity or molecular strength. As a sign of a solid's molecular structure, stress is at once a force of internal self-preservation and a force of identity, an innate faculty expressing the internal composition of a material object. Because stress expresses a material's identity or internal molecular composition, the distinctive elasticity (an object's total capacity for stress) of each form of matter may be scientifically measured, calculated and predicted. Thus, a steel beam will always support what a steel beam can support, provided its elasticity is not exceeded and its integrity compromised by stress cracking and fatigue. In this way, as Rankine devoted his professional life to demonstrate, architecture and engineering flow seamlessly from the philosophical research of the chemist and the physicist.

Yet in distinguishing external pressure from internal stress, Rankine created a division within force that would strike his audience as arbitrary and indefensible. For a physicist, such distinction between forces is redundant. External or internal, force is force and can be expressed by a single term. But for an engineer, the two forms of force are entirely distinct. The first makes a structure fall flat; the second causes it to stand upright. That Rankine was an engineer as well as a physicist appears in his eventual segregation of the two forces. In this, yet another link between Rankine and his engineering predecessors Robison, Gregory, and Barlow appears. Much as Robison, Gregory, and Barlow distinguished strain from force to accommodate human perception, and thus their discrimination between the two terms applies not to a difference in reality but to a difference in the observer's viewpoint or purpose in analysis, so Rankine distinguished internal stress from external pressure. As William Thomson was later to maintain, no inherent difference divides the cohesion of molecules within an object from the cohesion of other molecules outside the object. Yet while no inherent difference divides the two cases, an apparent difference does – the way reality is orchestrated by the human eye. Much as "strain" for Robison and Barlow depended on human perspective, so does Rankine's stress.

Rankine defined stress as described above in a Royal Society paper, “On Axes of Elasticity and Crystalline Forms” (1855). Three years later, however, in his acclaimed *A Manual of Applied Mechanics* (1858), Rankine disavows his idiosyncratic coinage of stress, and reverts to the conventional sense of the term. As he writes in his *A Manual of Applied Mechanics*, "The word stress *has been adopted* as a general term to comprehend various forces which are exerted between contiguous bodies” (68, emphasis mine). In so defining stress, Rankine abandons his engineer’s distinction between external pressure and internal stress, and collapses force, stress, and pressure together as precisely synonymous.

Nevertheless, Rankine’s phrase “has been adopted” suggests that in abandoning his distinctive sense of stress, he capitulates to the consensus of scientific writers instead of following his own proper inclinations. Most likely, this consensus was prompted by William Thomson, later Lord Kelvin, in a paper he read to the Royal Society in 1856, “Elements of a Mathematical Theory of Elasticity.” In many regards, Thomson’s paper parallels Rankine’s paper from 1855: both authors investigate the “distribution of force” among “axes of elasticity,” both derive twenty-one “coefficients of strain” from an “orthogonal system of six strains,” and both conclude their papers by applying their findings to natural crystals.[35] Likewise, both discriminate between stress and strain. But while Thomson accepts Rankine’s circumscription of strain, he sets aside Rankine’s redefinition of stress. As he clarifies in a footnote,

> These terms [stress and strain] were first definitively introduced into the Theory of Elasticity by Rankine, and I have found them very valuable in writing on the subject. It will be seen that I have deviated slightly from Mr. Rankine’s definition

[35] In so saying, I do not mean to imply that Thomson was merely translating Rankine’s thought. Influence was reciprocal, and Rankine, in his paper, cited Thomson prominently and repeatedly, along with other writers like George Green and James Joseph Sylvester.

> of the word "stress," as I have applied it to the direct action experienced by a body from the matter around it, and not, as proposed by him, to the elastic reaction of the body equal and opposite to that action. (481)

Most likely, Thomson objected to Rankine's reformulation of stress for the very reasons Rankine first redefined the term. While Rankine sought to distinguish or even estrange the scientific lexicon from ordinary speech, Thomson frequently collapsed distinctions between scientific and vernacular English, often by emphasizing the popular origin of scientific terms.[36] As well, as a physicist and not an engineer, Thomson most likely objected to what would have seemed to him as an arbitrary division of force. Thus, instead of treating external and internal pressures as opposed and distinct, Thomson regards "internal" and "external" states as relative with respect to scale – while pressures inside a brick may be internal with the entire brick in view, the same pressures become external from the perspective of a single molecule or atom. Thus, Thomson restored stress to its conventional meaning as precisely synonymous with pressure or force.

In so doing, Thomson at once set aside not just Rankine's lexical innovation, but the engineering tradition behind Rankine's term stretching from Robison to Gregory to Barlow and finally to Rankine. In collapsing stress with pressure and force, Thomson exorcises the active force resident within objects that sustains their integral coherence. While Thomson's revision of stress enabled the term to express the operations of force with greater consistency and broader scope, at the same time his revision banished appreciation of the object *as an object*, with a

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[36] For an example from the present paper, Thomson clarifies the meaning of *strain* by observing that "a ship is said 'to strain' if in launching, or when working in a heavy sea, the different parts of it experience relative motions" (481). He repeats this originary explanation of *strain* in his and Tait's *Treatise on Natural Philosophy* (116). As these instances suggest, Thomson's patterns of verbal usage departed from Rankine's in that he preferred keeping scientific language as close as possible to ordinary speech.

distinct form, structure, and being. In short, Thomson's emendation prompts speakers to regard the workings of force without regard to human perceptions of objects' scale, structure, and form. Integrated object or dissociated atoms, force is force. Gone was the human perspective of Robison, Gregory, Barlow, and Rankine that considered the integral unity of solid bodies. From Thomson's perspective, human estimation of form and feature was an imposition upon reality, and given that objects were nothing but associations of bonded molecules and atoms, form and feature should best be regarded as accidental qualities of molecular arrangement, not as intrinsic or predicated upon the nature of the object itself as a holistic entity.

Despite Rankine's capitulation, his definition of stress was not immediately banished by Thomson's. Philosophers and engineers employed both definitions alternately through the end of the nineteenth century. Indeed, Thomson himself used Rankine's definition in 1867 when, along with P. G. Tait in their *Treatise on Natural Philosophy*, he wrote "We adopt, from Rankine, the term stress to designate the forces called into play through the interior of a solid when brought into a condition of strain" (507).

Rankine's engineering disciples particularly championed their mentor's term. In 1880, W. J. Millar published Rankine's *Miscellaneous Scientific Papers*, for which P. G. Tait wrote a glowing introductory memoir. In his preface, Millar wrote that "the papers now published are of permanent value" (v-vi). Millar draws specific attention to Rankine's 1855 "On Axes of Elasticity and Crystalline Forms," observing that "In the Sixth Paper the distinction between *Strain* and *Stress* is made clear" (viii). The fact that Millar writes this in 1880 suggests that a contingent of engineers still preferred Rankine's nomenclature to Thomson's even twenty-two years after Rankine had adopted Thomson's redefinition of stress. Millar's preface indicates that

Rankine's definition of stress was, if not the primary understanding of the term, still in common use through the 1870's and into the 1880's.

Furthermore, according to an anonymous "Student's Column" in the February 3, 1900 edition of *The Builder, "*Rankine first introduced the term stress into mechanics about the year 1855. [. . .] Unfortunately, it happened in the following year that Sir William Thomson, now Lord Kelvin, applied the word stress as being synonymous with pressure" (118-9). The columnist's assessment that Thomson's redefinition of Rankine's term was "unfortunate" is reinforced several lines later: "Rankine's theory is to be preferred as presenting a truer picture of the interactive forces involved" (119). Nevertheless, the columnist admits, "[Thomson's] theory is more convenient and equally as serviceable for all practical purposes. Some writers adopt one theory, and some the other" (119).

Coupled with Millar's preface, the anonymous *Builder* columnist evidences that Rankine's definition of stress was alive and well – at least in engineering literature -- as late as the 1900's. Even more so, the *Builder* columnist demonstrates that the differences between Rankine's and Thomson's terms were generally understood (indeed, the "Student's Column" author apparently writes for the express purpose of informing engineering students about these differences), as were their respective merits and demerits. Moreover, both definitions contributed to scientific discourse, and were current through the end of the century. Scientific writers "adopt[ed] one [or] the other" definition depending on their purposes and personal preferences.

2.4 Summary

Scientific terminology is a product with a history. While stress and strain currently have stable and consistent meanings, this consistent stability results from a century of innovation spanning Robison's and Barlow's attempts to define stress and strength, Herschel's and

Faraday's misgivings about terminological imprecision, and Rankine's and Thomson's alternate articulations of stress. The last development particularly contrasts with the singular, unitary meaning of terms in modern scientific vocabulary. While the meaning of stress is now tightly defined, between 1858 and at least 1900, stress had two meanings that could be alternately invoked depending on circumstance.

But the most enduring application of Rankine's usage appears not in physical literature but in poetic. In the works of the poet-priest Gerard Manley Hopkins, stress describes the self-distinctive force by which objects preserve not only their material shape and form, but also their ontological being. To Hopkins' assumption of Rankine's term we turn in the next chapter.

3 STRESS AND STRAIN: ENERGY SCIENCE AND HOPKINS' POETICS

In the previous chapter, we have seen how Rankine drew on the technical literature of engineering and natural philosophy to articulate stress as a forceful and active expression of an object's elasticity in response to pressures threatening the object's coherence. Given that an object's elasticity stems directly from its molecular composition, stress then expresses the integral structure that gives the object its distinct being. Accordingly, stress for Rankine is an active expression of the object's structural composition called forth by external pressure. Moreover, it is an actual and active force maintaining an object's coherence and hence its existence.

While Rankine's materially essentialist notion of stress was undermined by William Thomson, a similar treatment of stress appears in the writings of Gerard Manley Hopkins. The present chapter will interrogate Hopkins' poetic terminology of stress and strain that has heretofore struck many critics as entirely idiosyncratic. In comparing Hopkins' usage of these words against the context of nineteenth century science writings, I will argue that the terms central to Hopkins' poetics can be understood as an imaginative reinterpretation of terms central to the engineering lexicon developed by Robison, Gregory, Barlow, and Rankine, and ultimately curtailed by William Thomson.

Hopkins' treatment of the relationship between an object's internal stress and its external shape and behavior prompts comparison of the poet's vocabulary with the engineer's. As in Rankine's works, stress functions in Hopkins' writings as a physical force inherent within objects and natural phenomena. Likewise, both Hopkins and Rankine consider stress an active expression of individual form, an expression that not only reveals the nature of an object but that preserves and maintains it as well. Yet while Hopkins' stress adheres to Rankine's usage apropos physical objects, it extends beyond the engineering tradition to encompass an object's (or being's) ontological or essential form in addition to its physical structure. Semantically, Hopkins' term begins with Rankine's but stretches beyond it, extrapolating from the physical to the metaphysical.[37] In the engineering tradition of Robison, Gregory, Barlow, and Rankine, while strength or stress seemingly, at times, approaches ontological signification, the authors restrict their terms to the mechanical and material nature of objects.[38] Thus, the engineers' strength and stress express the molecular or particular arrangements that make up an object, but make no claim of any form, structure, or being beyond the purely physical. For Hopkins, however, while stress is equally material, it spans the divide between the mechanical and the metaphysical and functions as a fully ontological term.

[37] By "physical," I mean "physics-ical." Thus Hopkins' term initially applies to relations of energy and force, the sort of relations studied by nineteenth century physics and physicists. However, in its furthest extension, Hopkins' term passes beyond physics and also applies metaphysically.

[38] Not all nineteenth century scientific authors were so circumspect in their distinction of mechanical science from metaphysical speculation. See chapter 5's discussion of P. G. Tait and Balfour Stewart's *Unseen Universe*.

In Hopkins' writing, then, stress scales the physical to the metaphysical, and simultaneously expresses the mechanical and vital force of each being. In conflating the material with the metaphysical, Hopkins participates in a general trend in nineteenth century psychology and art. Alan Richardson, in his *British Romanticism and the Science of the Mind* discusses the encroachment of "romantic brain science" on the traditional ground of metaphysics. In this work, Richardson investigates how the traditional prerogatives of the soul – thought, sensation, and desire – became progressively coterminous with the activity of the bodily brain and organs. Likewise, William A. Cohen, in his *Embodied: Victorian Literature and the Senses*, surveys Victorian artistic representations of the soul or personal essence. In his investigation, Cohen argues that Victorians, when they distinguished soul from body at all, often represented the soul in bodily terms. As Cohen writes, Victorian fiction often "represents interior being" as material, and thus "the soul consequently assumes the form of a tangible entity" (11). Cohen substantiates his claim by observing the materiality of ghosts or souls in a number of Victorian novels and poems, perhaps most pointedly in Emily Bronte's *Wuthering Heights* when Catherine's ghost "displaces air" with her sighs or when, in Heathcliff's dream, Catherine's ghost scrapes her arm against a window and bleeds (Cohen 12).[39]

Hopkins himself corroborates Richardson's and Cohen's observations. In his "The Probable Future of Metaphysics," Hopkins records that "the Positivists foretell and many other people begin to fear [that] the end of all metaphysics is at hand. Purely material psychology is the [conqueror] foretold and feared" (Higgins, *Oxford Essays* 287). Hopkins summarizes the

[39] Hopkins himself verifies Cohen's and Richardson's observations. In his essay "The Probable Future of Metaphysics," Hopkins writes that "the Positivists foretell and many other people begin to fear [that] the end of all metaphysics is at hand. Purely material psychology is the [conqueror] long foretold" (*Oxford Essays*, 287). Hopkins himself remained an idealist who believed in the soul, but his idealism incorporated positivist materialism.

characteristic Positivist tactic of "show[ing] an organ for each faculty and a nerve vibrating for each ~~thought~~ idea" (287). While Hopkins is not a Positivist, his metaphysics encompasses Positivism and lives at peace with it. Hopkins readily admits that the brain or another bodily organ may well govern the mental faculties, and that thoughts consist of "vibrating" nerves. But, Hopkins rejoins, "this merely shows in the last detail what broadly no one doubted, to wit that the activities of the spirit are conveyed in those of the body as scent is conveyed in spirits of wine, remaining still inexplicably distinct" (287). Although thought, desire, and sensation may legitimately be activities of the body or the embodied brain, they are better understood as activities of the spirit "conveyed" to the body. Thus, each of the soul's actions has a bodily counterpart, and the body corresponds to the spirit in all activities and faculties conceivable. Nevertheless, the spirit moves the body to act, and all of the body's activity begins in the spirit and is conveyed to the body by and from the spirit. In short, Hopkins reconciles metaphysics with Positivism without departing from the traditional definition of spirit – a principle of life animating the body.

While many critics have explicated the significance of Hopkins' stress and strain – as well as his related coinages instress and inscape -- none to my knowledge has systematically compared Hopkins' terms to the evolving registers of nineteenth century engineering and thermodynamics. The scholar that comes closest to doing so is Daniel Brown, and, indeed, the present chapter is indebted to his *Hopkins' Idealism: Philosophy, Physics, Poetry*. But while Brown was the first to trace the origin of Hopkins' term stress to Victorian energy science, he minimizes distinctions between how this and related terms were treated in the evolving register of the physical sciences. Particularly, Brown collapses Rankine's initial definition of stress with Thomson's revised definition of it. In Brown's defense, his purpose in writing was to rebut "the radical opposition of art [. . .] to mechanistic science [which was] a central presupposition of Anglo-American New Criticism" and which still exerted considerable influence in Hopkins' scholarship when Brown wrote in 1997 (Brown 200). Given this purpose, Brown's point was to demonstrate the symmetry between the terms of Victorian science and Hopkins' poetics, not to itemize distinctions between the ways scientists used these terms.[40] Yet in collapsing Rankine's and Thomson's definitions, Brown depletes Rankine's definition of stress of its mechanical vitalism, or its emphasis on a self-distinctive force resident within each object.[41] This chapter aims to assess Hopkins' poetics in light of the various contemporary meanings of stress, and will treat the word as a matrix of multiple and contested meanings instead of as a stable term with a single definition.

Such a reading not only situates Hopkins within his nineteenth century milieu but also reflects his theory of language in which a word functions as the "contraction or coinciding point" of several definitions (*Oxford Essays,* 306-7). Moreover, recovering the contested meanings of stress enables new interpretations of Hopkins' work or opens passages from his poems to additional nuance. Particularly, attending to Hopkins' metaphysical extrapolation of Rankine's

[40] Brown himself is aware of these distinctions, but they were not important for his argument in 1997. See pages 214-5 of his *Gerard Manley Hopkins: Philosophy, Physics, Poetry,* where Brown briefly touches on the distinctions between Rankine's and Thomson's definitions of stress and *strain.* But Brown's main task was to establish a core of conceptual unity for the term in scientific writing, and then to show this same unity in Hopkins' writing as well. In effect then, Brown collapses Rankine's and Thomson's definitions of stress, emphasizing their conceptual similarities instead of their distinctions. In Brown's words, "'Stress' refers in both Rankine's and Thomson's definitions to the tendency by which the equilibrium of a body is maintained" (215).

[41] To recap from the previous chapter, Rankine's and Thomson's definitions of stress agree in that each articulates the ways various forces act, react, and equilibrate each other. Yet Thomson's definition of stress makes no provision for the individual object, and declines to distinguish between pressures internal to the object and external to it – all are stress*es* alike. For Rankine's early definition of stress, however, the object is central, and the term stress is reserved only for those forces within the object that enable it to resist external pressures. An object's stress then is the force that it musters in response to external pressure. Stress then is the internal force that preserves an object's integrity, structure, and function.

term explains several of the images ubiquitous in Hopkins' poems and also clarifies his conception of the soul. More importantly, however, Hopkins' verbal extemporizations of stress illustrate the symmetry he saw between physics and metaphysics, between this world and the world beyond. Energy bridges the physical and the spiritual, and thus the motions of the physical world are susceptible to the divine impulse of instress or grace. The present chapter will illustrate Hopkins' usage of stress and discuss his physical metaphysics; the subsequent chapter will define Hopkins' instress and explain his field theory of grace.

3.1 Review of Scholarship

James Cotter, in his seminal monograph *Inscape: The Christology and Poetry of Gerard Manley Hopkins*, examines the Christian and classical contexts of Hopkins' stress and *strain*. Cotter explains Hopkins' stress in terms of the Greek philosopher Parmenides' concept of Being. Parmenides taught that a Universal Existence, or Being in an abstract sense, was the true reality and substratum of all phenomenological existence. Individual phenomena then, or the "Many," are extrusions from this singular and total ontological unity. In light of Parmenides' doctrine – and Hopkins' manifest interest in it -- Cotter defines Hopkins' stress, as "the ictus of being flowing from the world of objects, their knowability as projectiles of thought; [. . .] the bridge or juice through the stem of things, which impels us to acknowledge Being" (14). Stress then is a particular expression of Universal being, or, more precisely, the force or "pressure" by which Universal being expresses itself in the phenomenal world as a material object (278-9). Cotter links stress and *strain* in that, if stress is the expression or pressure of Being, *strain* is the quality of Becoming or coming-into-being. Cotter argues that for the classically-Christian Hopkins, Parmenides' Being is none other than Jesus Christ the Son of God, present within and undergirding the phenomena of his creation. If Christ is Being, the substratum of all phenomenal existence, then Christ's creatures result from an "outstress" of his Being. Stress then describes the divine energy responsible for a creature's creation and continued existence as a material thing; *strain* expresses the creature's continued development as it returns to Christ through moral obedience to him.

If the creature goes out from God through stress, it returns to him through *strain*. As Cotter writes, *strain* is an "inherited tendency toward Christ," or, in Hopkins' words, the tendency of "being [to draw-]home to Being" (Cotter 203; *Oxford Essays*, 314). In straining, creatures achieve greater self-definition yet paradoxically draw closer to Christ as the Universal pattern and telos of all created things. Cotter accordingly finds an analogue for Hopkins' term in Philippians 3:13-14 as well as in the writings of Gregory of Nyssa (203). Within this Christian context, *strain* connotes what Gregory termed *epectasis*, or the continuous effort in response to divine grace to draw ever more like and near to God (202-3).

J. Hillis Miller similarly investigates the ontological import of stress in his 1955 article "The Creation of the Self in Gerard Manley Hopkins." Miller describes Hopkins' term *inscape* as "Hopkins' word for the design or pattern which is the perceptible sign of the unique individuality of a thing" (300). *Inscape*, the sign of a thing's essence, results from the thing's stress, or the "vital pressure" that sustains the object "from within" (301, 302). Not a metaphor or a loose turn of speech, stress for Hopkins describes an ontological force, an "inward energy" responsible for producing a thing's identity and for "up[holding]" its very existence (304, 303).

Leonard Cochran crystallizes Cotter's and Miller's insights in a particularly lucid and systematic study, and adds to their investigations by differentiating stress from instress. For both Cotter and Miller, the term stress describes the vital energy that God communicates to a thing at creation by which it exists and maintains its hold on being. Thus, stress is an ontological force that causes things to exist as materially concrete objects. Cochran divides Cotter's and Miller's stress in two, identifying the first movement as stress proper and the second as instress. "The struggle to maintain existence is essentially a struggle to hold together," Cochran writes. "Stress is a struggle towards being *in genere*; it is the inherent nature of *being to tend to remain in* being, i.e., in existence. Instress is a struggle to hold *in specie*, i.e., the struggle of this thing to remain in being, to hold together" (160). Cochran subsequently clarifies these definitions, observing that "stress and *in*stress have several things in common. They both represent kinds of energy, stress the energy of the thing as it tends towards existence in general; instress the energy which keeps in existence the particular thing" (165). Thus stress affords an object the ability to be, or to exist in a general sense; instress affords an object the ability to be itself, or to exist as a particular, concrete thing.

Other than Cotter, Miller, and Cochran, several other scholars have articulated the ontological significance of stress. Norman MacKenzie defines stress as "the selving force within a being" (*Readers' Guide* 244). Likewise, W. A. M. Peters explains that "stress [marks] the force which keeps a thing in existence and its strain after continued existence" (13). In other investigations, however, applications to stress remain implicit, overshadowed by attempts to define inscape, another of Hopkins' notable coinages which Dennis Sobolev aptly identifies as "without a doubt [. . .] the most overdetermined word in the vocabulary of Hopkins criticism" (219). Notwithstanding, given the close relationships among stress, scape, instress, and inscape in Hopkins' philosophical poetics, a claim about of any of these terms necessarily impinges upon the others.[42] While this paper will refrain from further overdetermining inscape, it will provide

[42] Stress is not the same as *inscape*, yet the two are related. Stress is the root of Hopkins' term *in*stress, and *in*stress and *inscape* are companion terms. Volumes have been and continue to be written on these terms, but stress is usually considered to be, to recall Hillis Miller, the "vital

an etiological and cultural context for stress and instress, specifically grounding Hopkins' terms within the developing disciplines of the Victorian physical sciences.

Other scholars have perceived the musical or metrical applications of stress. Laura Gutman, in her study *Gerard Manley Hopkins and the Music of Poetry*, combines the musical and ontological senses of stress, defending her hybrid exposition of the term with a perspicacious account of Hopkins' linguistic practice: "Hopkins' usage of words," Gutman argues, "consciously combin[es] each word's various aspects to present [the word's essential self] as a coinciding-point of all its meanings" (76). Accordingly, Gutman argues that Hopkins conceives of human selfhood in musical terms, and that Hopkins' term stress advances "the musical string as analogy for man" (75). As Gutman explains, "Man is like a musical string, stretched upward from its base [. . .] to God. Depending on the tightness of the string, its pitch goes up or down" (75). The musical scale of nature contains all of the pitches of God's creatures, and the distinctive stress of an individual, or the "tightness of the string" that produces its *pitch*, is an intrinsically moral quality that determines the creature's proximity to its creator: "the more the stress or instress to the will, the higher the moral pitch [. . . .] Man is strung tight to a certain moral pitch as a string is tightened to its pitch" (75-6).

Similarly, Meredith Martin emphasizes the ontological import of Hopkins' metrical marks of poetic stress. Arguing that "understanding Hopkins' metrical marks is crucial to

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energy" of a thing active within the thing itself, while *in*stress is often taken as that energy outwardly expressed and received within by a percipient observer.

With Hopkins' term *inscape,* the plot thickens, and a discussion at least half a century old continues without abatement. In broad terms, and among many other subsidiary definitions, *inscape* is often treated as either a thing's essence (Scotus' *haecceitas*), or as the signs, expressions, or aspects of a thing's essence (Scotus' *formalitates*). For the prior position, see Pick, Peters, and Ellsberg. For the latter view, see Ward. Dennis Sobolev presents an exemplary summation of many of the formulations of *inscape,* along with the problems inherent within each, as well as offering his own attempt to reach a stable and universal definition.

understanding Hopkins' metaphysics," Martin demonstrates that Hopkins' system of metrical *marks* (a term that is itself fraught with Christo- and ontological significance for Hopkins) controls the stress, both syllabic and semantic, of Hopkins' lines, and consequently controls the poem's "assertion of being" (244, 246). Closely akin to Gutman's treatment of musical stress, Martin's analysis of stress emphasizes the term's related ontological and metrical meanings: "when stress is uttered, a word becomes being. [. . .] Hopkins implies that language, uttered in a certain way and perceived in a certain way, becomes an assertion of being" (246).

Another cluster of critics analyses Hopkins' stress alongside his Roman Catholic faith. Walter Ong first argued that Hopkins' sprung meter registered an attempt to return English prosody to the medieval, pre-Reformation age of English Catholicism. Thus, the rough metrics of Hopkins' sprung rhythm recalls the poetry of England's Catholic period "before the 'reform' and 'smoothing' of English numbers principally under the influence of Edmund Spencer" (170). Geoffrey Hill adapts Ong's argument to explain the strangeness of Hopkins' meter as one instance of the pervasive estrangement of a Catholic convert in Protestant England. As Hill writes, Hopkins, in converting to Catholicism, "suffered an abruption of his familiar rhythm" manifested not only in Hopkins' estrangement from his Protestant countrymen but in his poetry's novel system of stress in the form of sprung rhythm. Similarly, Eric Griffiths applies Hill's insight more broadly, explaining Hopkins' poetic efforts as a missiological attempt to acclimate his countrymen to a new form of Catholic prosody, thereby acclimating them to the oddness of Catholic language and belief: "The unfamiliar language of Catholicism had to be seen and heard as truly English speech, not as something unutterably alien, if the convert's voice was to be persuasive to the as yet unconverted" (267). Most recently, Joseph Pizza has argued that the strangeness of Hopkins' sprung rhythm "can be understood as accentuating the strange, and, even self-estranging, ambivalence that Hopkins and many of his fellow converts felt in becoming English Roman Catholics" (58).

The above sampling of Hopkins scholarship suggests the broad applicability of stress in Hopkins' ontology, theology, epistemology, musicology, and prosody. Yet while many critics have probed individual applications of these terms, few have asked how the disparate usages hold together, or have considered how, in Gutman's phrase, the single term stress coheres as a "coinciding point of all its meanings" (76). Such an investigation entails a study of the term's etiology for Hopkins, or of the various meanings and significations of the word available to Hopkins in his contemporary culture of Victorian England.

In this effort, several sources mentioned above point the way. To return to Cotter, in addition to his classical and patristic exposition of stress and strain, Cotter repeatedly implies a scientifically physical dimension of the terms. Thus, at one point Cotter explains that "the Spirit channels out the stress and energy which have been gathered and foredrawn in Christ" (70). In treating "stress" and "energy" as synonymously parallel, Cotter hints that Hopkins' language may be drawn from physical science as well as from Greek literature and Christian theology. Other instances of scientific allusions sprinkle Cotter's text: "Man forms [. . .] a nucleus of centrally charged and positive energy, massing reality with the mind, the focus of stress" (272); "Instress then involves centrifugal motion from, and inscape centripetal motion toward, a center, a stem of force shooting outward or converging inward" (275); "Like an in-stressed steel rod the lines of force meet, counterpoise, and give way in kenosis – and the pleroma bursts into being as Omega" (278); "Instress may be further defined then as the literal exterior force (the "stress" of "stars and storms") which, delivered through the senses and converging on the mind, results in inscape, the shaping of fresh incarnation in the new man" (278). Several of the passages cited above admittedly may be metaphorical, yet in his final definition of "stress" as a "literal exterior force," Cotter anticipates (whether knowingly or not) recent criticism recouping the symmetry between Hopkins' poetry and Victorian energy science.[43]

Much the same may be said of Miller. While his definition of Hopkins' instress as a "spiritual force" may initially seem metaphorical, this same "spiritual force" of instress "up[holds] each thing" in being, and is accordingly responsible for the continued existence of phenomenal things (304, 303). As such, this force of instress, though spiritual, is as real as the things themselves are. As a plenum of spiritual, yet real, instress, the world consequently "is a vast network of electrical discharges given and received by objects which are an inexhaustible source of the divine energy" (304).[44] The very fact that Miller, following Hopkins, speaks of the

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[43] For a similarly proleptic source, see Claudette Drennan's treatment of stress in her 1956 essay "A Critical Analysis of Hopkins' 'That Nature is a Heraclitean Fire, and of the Comfort of the Resurrection.'" Following Hopkins, scholars prior to the 1990s often explained stress and instress through metaphors drawn from physical science. At times it can be difficult to determine how metaphorically these scholars intended their language to be taken. For example, as Daniel Brown points out, Leonard Cochran consistently uses the language of mechanics to describe stress (at one point Cochran goes so far as to state that stress "carries [. . .] the connotation of a *dynamic* rather than a passive or *static* being"), yet makes no overt connection between stress and physical science or any form of physical energy (149, my emphasis). Brown blames critics' "suppress[ion]" of the scientific derivation of Hopkins' terminology on "the radical opposition of art [. . .] to mechanistic science" that originated with the Romantic poets and descended to "Anglo-American New Criticism" (200). Yet while Brown's criticism is convincing, it is unnecessarily harsh, and minimizes previous critics' important work of elaborating Hopkins' poems and his central poetic terminology of inscape and instress.

[44] By "real," I mean "somehow existing in such a way as to affect physical, material objects." Whether instress itself is "material" or "physical" depends on one's definition of these words. These words have been variously defined by philosophers.

See also William Cohen's "Subject: Embodiment and the Senses" in his *Embodied*: *Victorian Literature and the Senses*. In this chapter, Cohen explores Victorian conceptions of body and spirit, with especial attention to the trend in Victorian literature to consider the spirit as material. In Hopkins' frequent likening of instress to electricity, Hopkins instances another example of this Victorian trend, particularly so given the centrality of electricity to what Rankine dubbed as the "science of energetics."

spiritual energy of instress in terms of the physical energy of electricity underscores the fact that instress is an actual form of energy itself.

Such early explications of stress prepared later critics to analyze more closely Hopkins' treatment of science. While many of these critics do not address stress specifically, their work deserves mention in any account of science in Hopkins' writings. James Leggio, writing in 1977, was among the first to examine Hopkins' poems for explicit scientific reference. In Hopkins' Oxford poems, Leggio hears echoes of the Victorian physics of thermodynamics, arguing that "a number of [Hopkins'] undergraduate poems deal with entropic conditions" (60). Leggio accordingly interpretes several of Hopkins' undergraduate poems – "A fragment of anything you like," "I am like a slip of comet," and "Summa" – in terms of the entropic apocalypse predicted by the second law of thermodynamic physics.

Yet Norman MacKenzie and Allison Sulloway call for caution, particularly regarding Hopkins' early poems. Surveying Hopkins's Highgate and Oxford notebooks, essays, journals, and sketches, Mackenzie notes "Hopkins' surviving essays [. . .] occupy many note-books, but a scrutiny reveals how seldom the topic [bears] any conceivable relationship to the scientific world which was shaping itself beyond the charming medieval towers" (53). Mackenzie credits Hopkins' perspicacious observations of Nature to his inquisitive disposition and naturally perceptive – though scientifically untrained – senses. In MacKenzie's view, Hopkins during his Oxford years was a careful observer of appearances in Nature, despite his "almost total lack of formal contacts with any branch of science" (54).

Allison Sulloway corroborates MacKenzie's judgment. In her *Gerard Manley Hopkins and the Victorian Temper*, Sulloway compares Hopkins' nature journals to Ruskin's writings, finding that Hopkins, adopting Ruskin as a conscious model, studied Nature as a disciplined aesthete instead of as a scientist. As Sulloway argues, Ruskin's dictum "there is a science of the aspects of things, as well as of their nature" splits the "science of aspects" apart from the "science of essences" and offers a precise framework for Ruskin's (and Hopkins') aesthetic project: to understand the aspects of Nature as they appear to the senses of a sympathetic observer, not to pry into the actual mechanics or structural principles by which they work (Ruskin, Modern Painters III, 314).

Gillian Beer, however, in her 1991 "Helmholtz, Tyndall, Gerard Manley Hopkins: Leaps of the Prepared Imagination," tentatively surveys Hopkins' private and informal contacts with science as an undergraduate, pointing out that he could have accessed the thermodynamic theory of Hermann von Helmholtz through a number of avenues both public and personal, including the popular writings of John Tyndall, the public lectures of Hopkins' favorite linguist, Max Müller, and the private instruction of Hopkins' tutor, Walter Pater. Beer accumulates similar details as she follows Hopkins through his post-Oxford Jesuit training, amassing probability to justify her scientific readings of Hopkins' late poems, "The Blessed Virgin compared to the Air We Breathe" and "That Nature Is a Heraclitean Fire and of the Comfort of the Resurrection."

Likewise, Tom Zaniello examines Hopkins' early writings for implicit parallels with contemporary developments in natural science. Specifically, his *Hopkins in the Age of Darwin* (1988) recoups the intimations of Darwinian naturalism in Hopkins' Oxford essays (1863-68), illuminating the young poet's Oxford-era terms "diatonic" and "chromatic" in light of Victorian concerns with progress and flux. In the second half of the monograph, as well as in a series of later articles published in the 1990s, Zaniello turns from Hopkins' naturalism to his natural philosophy (physics). Zaniello describes Hopkins' extracurricular tuition at Stonyhurst Seminary between 1870-3, where he spent many hours in the Stonyhurst Observatory working with two well-respected meteorologists and astronomers, Fathers Stephen Perry and Walter Sidgreaves.

Thanks to Zaniello, Darwinian readings of Hopkins' poems, early or late, are now generally acceptable. Physical or thermodynamic interpretations, however, are viewed as biographically tenable only of Hopkins' latter poems, post-Stonyhurst. Physical readings of Hopkins' poems composed prior to 1870-3 are still regarded with suspicion.

Accordingly, MacKenzie's and Sulloway's skepticism, particularly regarding physical science, still appears in recent critics' treatment of Hopkins' early work. In a 2007 article, Marie Banfield insightfully discusses the symmetry of evolutionary and physical theory in mid-nineteenth century scientific discourse. As Banfield claims, evolution and thermodynamics, far from distinct theories of discreet scientific disciplines, were parallel iterations of the "translations and transformations of nature's forces," and shared common roots in the atomist philosophy of flux and Victorian narratives of development (Banfield 180). To prove her claims, Banfield traces the simultaneously Darwinian and thermodynamic register of Hopkins' poems. Tellingly, however, when Banfield discusses Hopkins' undergraduate work, she dilates the Darwinian features and collapses the thermodynamic. Banfield treads lightly on the thermodynamic qualities of Hopkins' early poetry, discussing his early poems cursorily while relying on his later work to carry her claims.

Jude Nixon's treatment of Hopkins' thermopoetics is similar. Nixon is forthright in his judgment that Hopkins knew about contemporary physics while at Oxford: "Hopkins' Oxford poems (1863-67) exploit the general energies of the universe" (Nixon, "Death blots" 134). All the same, Nixon treats the Oxford poems in a single paragraph, and devotes the remainder of his article to a close examination of Hopkins' post-Stonyhurst writings. In Nixon's own words, though the undergraduate poems suggest Hopkins' general awareness of energy science, the "poems written during and after Hopkins' Stonyhurst years (1870-73) exhibit a more direct embracing of thermodynamics" (134).

Daniel Brown's influential 1997 study *Hopkins' Idealism: Philosophy, Physics, and Poetry* offers the most extended explication of physical science in Hopkins' poetry. Unlike most critics, however, Brown argues forthrightly that even as an undergraduate, Hopkins knew and understood the physical theories of Victorian energy science. Brown particularly scrutinizes Hopkins' terms stress and instress, arguing that Hopkins transposed stress directly from the writings of William Thomson, and that the derived term instress expresses the unique combination of stresses within an object. Thus, if stress denotes the natural forces which inhere in all things, instress refers to the unique balance of forces that furnishes a thing's identity and character. Simply put, all things result from identical forces in nature; variety results not from different forces but different combination of forces. Things consist as the product of composite forces, then, or as the "equilibrium [of energies] which may be said to constitute [a thing's] definitive instress" (219).

This chapter takes its cue from Brown and others, and seeks to situate Hopkins' terminology of stress and strain within Victorian mechanical science and energy physics. In so doing, it will ground previous critics' expositions of stress and instress as ontological terms. As the above survey of literature suggests, critics universally agree that stress, in its multifaceted applications within Hopkins' work, inevitably expresses ontology. Critics have perceptively explored the prepossession and extensions of the term, but their efforts beg the question of why the word stress?[45] What about the word's usage in contemporary Victorian England suggested it

[45] "Prepossession" and "extension" are Hopkins' terms. See Lesley Higgins' edition of Hopkins'

to Hopkins as a suitable vehicle for his metaphysical speculations and ontological theory? In other words, when Hopkins wanted to express ontology and Being, why did he choose the word stress instead of another, more traditionally philosophical term? Additionally, what underlying connection between Being, music, poetry, and physical and mechanical force does the word stress supply? And finally, how does Hopkins respond artistically and intellectually to his contemporary context? This and the following chapters will explore these questions.

Additionally, with the work of Leggio, Beer, Zaniello, Banfield, Nixon, and Brown, this chapter tentatively suggests that the young Hopkins knew more about physical science – specifically mechanics – than he is often given credit for. In this chapter, I compare Hopkins' usage of stress to the engineering understanding of the term as first articulated by W.J.M. Rankine. Given that many of the instances – particularly the 1868 "Parmenides" notes -- in which Hopkins used the term "stress" date to a time before his Stonyhurst Philosophate (1870-1873), Hopkins' language suggests early familiarity with physical science.

In positing stress and strain as derived from the contemporary Victorian context of engineering and physics, I certainly do not mean to question or challenge the other meanings of these terms that scholars have previously discovered. Rather, I wish to show how Hopkins adapted the emerging tradition of Victorian physical science to previous Christian and classical traditions to yield a fecund poetic register. Hopkins' words typically express a pleroma of meaning, and it would be a mistake to posit one signification at the expense of others. If Hopkins' linguistic usage accords with his poetic practice, then he is interested in the intersection and patterning of terms and meanings, or in the ways all things spare and strange lace, lance, and pair.

Oxford Essays and Notes, pgs. 306-8.

3.2 Group versus Individual: Hopkins' Theory of Language

Hopkins' caudal sonnet "That Nature is a Heraclitean Fire and of the comfort of the Resurrection" often features in critical discussions of Hopkins' religious eschatology, ecocritical sensibility, and – most recently – thermodynamic poetics. But the sonnet also illustrates Hopkins' taxonomy, or the way he relates individuals to a group. Not only is Hopkins' taxonomy critically important to understand his poetic celebration of the "sweet especial" scenes of nature and the "dappled" inscapes of creation, but it is also important to his theory of language and his understanding of the relationships between a word's core – the "contraction or coinciding-point of its definitions" -- and its various "sides" or "sidings" or "extensions" ("Binsey Poplars"; "Pied Beauty"; *Oxford Essays,* 306).

In rough terms, the sonnet describes Hopkins' dismay at the loss of beautiful things in Nature. It opens with a winsome description of clouds traversing the sky. Hopkins' feeling for the clouds appears in his speaker's personification of them. These clouds are not merely bodies of evaporated water – they are "heaven-roysterers" on holiday, thronged in "gay-gangs"; they are mounted knights "chevy[ing] on an air--/Built thoroughfare"; they are armed troops that "glitter in marches."

From the clouds in the sky, Hopkins' narrator lowers his gaze to the branches of trees. "Wherever an elm arches," he writes, "shivelights and shadowtackle in long lashes lace, lance, and pair" "down roughcast, down dazzling whitewash" (3).[46] In the sun's light, the elm's branches cast shadows on the broken-textured surface of a roughcast wall or on the glistening surface of a whitewashed fence. The elm branches and twigs do not occlude the light completely, but cast long, thin rope- and spear-like shadows upon a field of light. The shadowropes and

[46] The *OED* defines "roughcast" as "a semi-fluid composition of lime (or later cement), water, and fine gravel, used as roughly textured plaster on the outside of a building" ("roughcast," 2a).

shadowspears "lace" and "lance" the light, and "pair" when they cross. Hopkins' dapple, or the play of light, shadow, and shape ubiquitous in his poetry, puts in another appearance in this poem in the "shivelights" and "shadowtackle" that pie the surface of the wall or fence.[47] The interplay of light and shadow is kaleidoscopic, changing with the wind that tosses the elm branches and the light itself as the sun runs its course through the sky. Like the clouds, the shadows drift and alter, and typify the impermanence of the natural world indicated by the title: nature is a Heraclitean fire.

From the sky to the treetops to walls and fences, the speaker at last turns his gaze to the ground. He looks at a mudpuddle or "rutpeel" – the top-most layer or "peel" of mud in a rut – and observes how the "bright wind boisterous ropes, wrestles, beats earth bare/ Of yestertempest's creases" (5-6).[48] The wind desiccates the ooze of the mud to "dough," then "crust," and finally to "dust." He sees some footprints -- the "manmarks" that "treadmire toil" (walking) has "footfretted" in the rut – in the mud, but the wind soon "stanches" them (8-9). Clouds and shadows drift and alter, and footprints weather away. While disparate, each of nature's selves has one thing in common with the rest: dissolution. As in Tennyson's lament in *In Memoriam,* the scapes and selves of nature expire while "Million-fueled, nature's bonfire burns on" ("Heraclitean Fire," 9).[49]

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[47] Note Hopkins' continuation of his rope and spear imagery in the "shivelights and shadowtackle" of the shadows. The OED lists Hopkins as the originator of the term "shivelight," which it defines as a "sliver of light" ("shive," compounds). Given that a "shive" or "shiver" is a splinter of wood, the "shivelight" corresponds to the spear- or shaft-like imagery of his verb "lance" later in the line. No definition appears for "shadowtackle," but given the association of tackle with ropes, the term probably refers to the rope-like quality of the shadows, and thus corresponds to his noun "lashes" and his verb "lace."

[48] Ropes appear once again in the poem in the way the "bright wind" furrows the muddy ooze.

[49] Hopkins often treats trees, clouds, and even places or scenes as individual and irreplaceable selves. For example, the trees in "Binsey Poplars" presented, before their felling, a "sweet especial scene." When the hewers fell the trees, they "unselve" this "sweet especial scene" (22,

Emotional intensity builds as the sonnet approaches its theme. The narrator's gaze shifts from sky to earth, and from shadows of trees to footprints of human beings. At last, at the end of an extended octave, the poem finds its center: "But quench her bonniest, dearest to her, her clearest-selved spark/ Man, how fast his firedint, his mark on mind, is gone!" (10-11).[50] All sparks flame out in nature's bonfire, but the spark of the individual human being is most precious. The "Manshape" of the human self "[shines] sheer off, disseveral" from all other selves in nature (12-3).

From the proposition of the elongated octave that nature is a Heraclitean fire, the 10.3-line sestet moves to the comfort of the resurrection. Nature's bonfire exhausts the sparks caught in its blaze, but the resurrection restores their living fire. "Enough!" the speaker announces –

> the Resurrection/ A heart's-clarion!
>
> Away grief's gasping, joyless days, dejection. [. . .]
>
> In a flash, at a trumpet crash,
>
> I am all at once what Christ is, since he was what I am, and
>
> This Jack, joke, poor potsherd, patch, matchwood, immortal diamond,

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21). As Hopkins saw it, a "self" is any expression of singular, cohesive being, whether sentient or inanimate. Not all selves are created equal, however, and in the words of "Heraclitean Fire," the more conscious or "clearly-selved" the individual, the "dearer" and "bonnier" it is.

[50] Hopkins' sonnet is a caudal sonnet, exceeding the typical sonnet's length but precisely preserving its proportions. The octave (if I may use the term) stretches from lines 1-13.7, and the sestet from 13.7-24. In this scheme, Hopkins' precision appears in that line 13 does not divide in a half-line. Rather, if "Manshape" begins the sestet, then by my scansion it is preceded by 5 stresses, and it itself is the sixth stress of a seven-stress line. Thus, "Manshape" occurs roughly seven-tenths of the way through the line, and the proportion of octave to sestet in Hopkins' 24-line sonnet precisely duplicates the proportion of octave to sestet in a traditional 14-line sonnet: 8/6 = 13.7/10.3 = 1.33. Nor am I being more fastidious than the poet: Hopkins was fascinated by the proportions of sonnets, and frequently described sonnets mathematically. In his "Author's Preface," he describes a curtail sonnet as follows: "12/2 + 9/2 = 21/2 = 10 1/2." Likewise, in a letter to his friend Canon Dixon, he describes "the equation of the best sonnet" as "(4+4) + (3+3) = 2.4 + 2.3 = 2(4+3) = 2.7 = 14" (*Correspondence* 71).

Is immortal diamond. (15-16, 17-20)

Oddly, in the chemically reactive logic of the poem, Heraclitus' fire brings about the resurrection.[51] Carbon transforms to diamond under heat, and the Heraclitean fire changes the speaker's "matchwood" to "immortal diamond." Moreover, "at once" is a pun – much as the sestet turns the Heraclitean bonfire from an engine of flux into an engine of resurrection, it turns the speaker from matchwood to matchwood and immortal diamond at once. The resurrection redeems the Heraclitean flux, and transforms – even before the fact – what once was just matchwood into matchwood that is immortal diamond in the making. Still in the midst of the Heraclitean fire, the speaker is potential immortal diamond even in his actual state of matchwood. Thus, the speaker not only changes "at once" from matchwood to immortal diamond, but he is "at once" matchwood and immortal diamond already. In the moment of the "trumpet crash" on the last day, "this Jack, joke, poor potsherd, patch, matchwood, immortal diamond" becomes "immortal diamond" pure and simple (17, 19-20). If the resurrection can be dated to a precise point in the poem, it occurs in the twinkling moment as the penultimate line gives over to the last. But the speaker is already "immortal diamond" in the penultimate line. Much as the last line omits the matchwood but preserves the immortal diamond, the resurrection realizes, ultimately and completely, the potential of each human being.

The foregoing summary touches upon several leitmotifs of imagery, tone, and theme in Hopkins' poetry: ropes and spears, the dapple, self-deprecatory humor, faith challenged by hardship, joy in the beautiful forms of nature and grief at their passing, and temporal flux in time building to the final "change" of the resurrection at the end of time. As well, the sonnet illustrates another recurrent theme in Hopkins' writings: spiritual realities are described as

[51] See D.C. Haggo's "Hopkins's 'Immortal Diamond': A Poetic Use of Science" for an insightful discussion of the chemical logic of the poem.

resulting from and extending beyond physical laws and material processes. Thus the Heraclitean fire is a heat engine transforming the speaker's matchwood to immortal diamond, and it is also an engine of time and change driving toward the final change of the resurrection at the consummation of time.

The sonnet also displays Hopkins' typical taxonomy of individuals and groups, a taxonomic system that helps to explain the function of words in his theory of language. In a notebook entitled "Notes on Greek Philosophy," Hopkins outlines a sketch of his philosophy of words:

> To every word meaning a thing and not a relation belongs a passion or prepossession or enthusiasm wh[ich] it has the power of suggesting or producing but not always or in everyone. [. . .] The prepossession [. . .] is in fact the form [of the word], but there are reasons for being cautious in using form here, and it bears a valuable analogy to the soul, one however wh[ich] is not complete, because all names but proper names are general while the soul is individual. (*Oxford Essays*, 306)

To paraphrase the above, each word that names an object has acquired a "prepossession of feeling" (Hopkins later links prepossession to connotation) that elicits an emotional response from an audience (306). This "prepossession" is the form or soul of the word. Yet while souls are individual, common nouns – "words meaning a thing" – are general. Thus, the word "man" or "manshape" in Hopkins' Heraclitean sonnet does not express a particular person, but humanity as a group.[52]

Since a common noun is general, it possesses another "moment" or "term belonging to it"

[52] I will modify this claim shortly. For now, I am merely discussing what the word itself means, not Hopkins' meaning in the poem.

(*Oxford Essays*, 306). Hopkins names this moment the noun's "application, 'extension,' the concrete things coming under it" (306). Extension describes the correspondence between the name or word for the group and the specific things that belong to the group. The word "man," for example, is a general term that names a group of featherless bipeds, but it can be applied or extended to any particular human being. Similarly, Hopkins' word "manshape" has a number of extensions, equal to the number of human beings that have existed or will exist in the world.

In his extraordinary sonnet, Hopkins names humans as a group, yet the "selving" or individuality of human beings is critical to the sonnet's meaning and central to the redemption of its potential tragedy. In the language of his "Notes on Greek Philosophy," Hopkins' words "man" and "Manshape" name a group, but his chief concern is with the extensions of those terms, or the individual men and manshapes that collectively form humanity. To quote the lines germane to the present discussion,

> Million-fueled, nature's bonfire burns on.
> But quench her bonniest, dearest to her, her clearest-selved spark
> Man, how fast his firedint, his mark on mind, is gone!
> Both are in an unfathomable, all is in an enormous dark
> Drowned. O pity and indignation! Manshape, that shone
> Sheer off, disseveral, a star, death blots black out; nor mark
> Is any of him at all so stark
> But vastness blurs and time beats level. Enough! The Resurrection, … (9-15)

Hopkins names the collective as a shorthand way to describe each individual within it. His celebration of "man" as nature's "clearest-selved spark," as well as his imagery of individual sparks and "fire-dints" within nature's bonfire, suggests that his real concern is with individual humans. The collective nature of humanity is to be individually distinct, and thus “Manshape” not only differentiates human nature in general from the cosmos, but the shape of an individual man from all others. If the sonnet is “careful of the type” but “careless of the single life,” then nothing is lost for the resurrection to reclaim: the individual dies, but the group lives (provided, of course, that not all of the individuals die at the same time) (Tennyson, *In Memoriam* 55. 7, 8). Given that Hopkins does feel loss despite the persistence of the type, and given that the resurrection does redeem human sorrow, then the poem concerns the individual.

Hopkins’ portmanteau coinage “disseveral” further illustrates the individuality of “Manshape.” As I interpret the word, it is an adjectival form of “dissever” describing something that is distinct or separate. In the line from “Heraclitean Fire,” “disseveral” complements the phrase “Sheer off.” In what I take to be its primary function within the line, “Sheer” is an adjective, but “sheer off” recalls the verb “shear” or “to cut.” (Hopkins always claimed to compose his poems for the ear, not the eye, it should be remembered.) Thus, “dissever-al” and “sheer off” cooperate to indicate something that is separate or cut away from others. In addition to acting as an adjectival form of “dissever,” however, “disseveral” is also a portmanteau term merging “dissever” with “several.” According to the *OED*, in addition to meaning “more than one,” several also means “distinctive, particular” (*OED* A.I.2.d; A.I.1.c) As such, it connotes multiplicity but also particularity. In “Heraclitean Fire,” then, when Hopkins applies the term “disseveral” to “Manshape,” he means the “distinctive, particular” mold of “Manshape” for each human being, unique and separate or “cut away” from every other individual’s especial being. Each man, and not merely humanity as a whole, is “a star” in the sky of nature, or a “spark” or “firedint” in “nature’s bonfire.”

Though all humans descend from a common root, each person “selves” individually and is distinct from other human beings. Similarly, though all of a word's extensions follow from a collective prepossession, each extension is a concrete particular in its own right. Like other poets – one might remember Milton's equation of a "good book" with the "lifeblood of a master spirit" – Hopkins classifies words much as he does human beings. His association of words with people perhaps explains his claim that a word's prepossession or "form" "bears a valuable analogy to the soul" (*Oxford Essays*, 306).

In addition to prepossession and extension, words have a third term -- definition.[53] Much as a single prepossession generates multiple extensions, so a single word generates many definitions. As Hopkins relates, "every word may be considered as the contraction or coinciding-point of its definitions" (*Oxford Essays*, 306). Thus, "manshape" has been historically defined as the image of God, a featherless biped, a reasoning animal, an evolved hominid, a dualism of matter and spirit, and a complex of nerves and chemicals. Yet provided that these definitions are not false or mutually exclusive (in actuality they well may be), they faithfully define the same word, and the word's meaning, in total, should be considered the sum, contraction, or coincidence of each of its subsidiary definitions. A word is a unity of disparate definitions, then, with each definition describing an aspect or "side" of the word's total or collective meaning.[54]

[53] To be more precise, definition is part of the second term ("utterance") of a word, and extension is the third term. I am explaining Hopkins' theory of language out of sequential order. In the next chapter, I explain Hopkins' trinitarian theory of language in more detail and restore the terms to their proper order.

[54] While "side" and "siding" are conventional words, Hopkins uses them several times in his writings in a new sense to express an aspect or nuance of a thing or of a word's meaning. See *Journals*, 130: "For the phenomenal world [. . .] is the brink, limbus, lapping, run-and-mingle / of two principles which meet in the scape of everything – probably Being, under its modification or siding of particular oneness, and Not-being, under its siding of the Many." See also 211: "A beautiful instance of inscape sided on the slide, that is/ successive sidings of one inscape, is seen in the behaviour of the flag flower from the shut bud to the full blowing: each term you can distinguish is beautiful in itself and of course if the whole 'behaviour' were gathered up and so stalled it would have a beauty of all the higher degree." Again, see 267: "That [a pattern of

Thus, the several (or "disseveral," perhaps) and particular definitions of a word "contract" or "coincide" to form a rich aggregate core: "every word may be considered the contraction or coinciding-point of its definitions" (306).

Hopkins' tripartite theory of words resembles a solar system in which meaning shuttles two ways, radiating outward from the core and falling back into it. In terms of extension, meaning radiates outward from the word's core prepossession to the "things coming under it," or from the idea of the word to its physical instances and permutations. In terms of definition, however, meaning flows inward from the peripheral definitions toward the aggregate core. Given that a "word [is] the contraction or coinciding-point of its definitions," the various subsidiary or "orbital" definitions fall back to the core to supply it with a rich, collective meaning. Yet this two-way movement is complementary, as is the relationship between a word's definition and its extension.[55]

Hopkins intended his three-fold theory of language to apply to "every word meaning a thing and not a relation" (*Oxford Essays,* 306).[56] Pertaining to stress, while stress may be

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speech] may be marked it must be repeated at least once, that is/ the figure must occur at least twice, so that it may be defined/ Spoken sound having a repeated figure. (It is not necessary that any whole should be repeated bodily: it may be *sided off*, as in the metres of a chorus, but then *some* common measure, namely the length of a ᴜ or – or strength of a beat etc, recurs)."

[55] In this sentence, I collapse Hopkins' second moment (utterance/definition) with his third moment (extension). Yet given that our ways of defining a word are shaped by the instances of the word that we see (in other words, our definition of a common noun depends on the instances that we know of that noun), the overlap between the two terms seems inevitable. Although each "side" or subsidiary definition should reside in each instance or extension of the noun, certain instances/extensions express a side more clearly or forcefully than others do. To advert once more to the traditional ways of defining a human being, some people are more expressive of God's image than others, some are more rational than their peers, some are more neurotic, etc. Thus, while the divine image, reason, and nervous chemistry are sides of every human existence, some people express (and alternately suppress) a particular side more forcefully than other people do. Accordingly, definition follows experience, and a definition of a noun reflects the instances of that noun that have been experienced.

[56] It is possible to read Hopkins' phrasing to mean that he restricted only the first term –

considered a relation between things instead of a thing in itself, Hopkins' lifelong philosophic inquiry into the subject suggests that it is at least an object of thought if not an object of sensation. Furthermore, Hopkins' complex treatment of stress suggests that he perceived the word in terms of his linguistic model, as a core of meaning with various coinciding definitions, and as a root term with far-reaching extension. In what follows in this chapter, I will attempt to articulate the core meaning of stress as a coinciding point of its various definitions, and to trace its various extensions that ray out from a contracted point of meaning. In so doing, I will demonstrate the centrality of Rankine's stress to Hopkins', and argue that Rankine's understanding of stress as an active expression of material structure is central to Hopkins' core definition of the term.

3.3 Hopkins' Definitions of Stress

Stress for Hopkins is a many-sided thing. Like other words, however, despite its far-flung extensions, its several definitions orbit a central core. In attempting to define this core and its various extensions, I will follow Laura Gutman's useful formulation that Hopkins "consciously combin[es] each word's various aspects to present [the word's essential self] as a coinciding-point of all its meanings" (76). In examining the various ways Hopkins uses the word stress, I will attempt not only to define particular instances of the word but also to illustrate their correspondence to a collective or unified understanding of stress. In articulating this "contraction or coinciding-point of [the] definitions" of stress, I will furthermore show the centrality of Rankine's usage to Hopkins', or show how Hopkins' contraction-point for stress resembles Rankine's definition of the word (*Oxford Essays*, 306). In fine, I argue that although stress' total

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prepossession – of his three-fold theory, but not the second and third terms. In this case, even if stress is considered a relation instead of a thing, the latter terms (utterance/definition and extension) would still apply.

definition is a nucleus with wide-ranging orbits, at its core stress expresses a vital force of being that is at once material and vital, mechanical and ontological. Hopkins' fundamental understanding of stress resembles Rankine's usage, yet stretches beyond it to encompass the metaphysical as well as the physical.

3.3.1 Stress as Force

In its furthest extent from the core, stress merely means force.[57] Stress in this sense spans Hopkins' writings, from his early poems and journals to the works composed late in life. Certain

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[57] I exclude (perhaps in error) from my analysis Hopkins' casual or commonplace usages of stress such as "to lay a stress to" or "He stressed that." In these casual phrases, stress means "to emphasize," and doesn't necessarily carry any sort of special or technical resonance. All the same, Hopkins' technical senses of the term most likely colored his commonplace usages. At any rate, were I to examine his casual use of the word, I would assign it to the most peripheral orbital, beyond the one described in the paragraph above.

In distinguishing stress' core from its periphery, one is faced with a definitional challenge. Does the core consist of the most generalized or specialized definition of stress? If the former, then the central definition will be shared as the least common denominator of the peripheral definitions, and thus the word may be mapped as a series of concentric circles or orbitals, the innermost reflecting what is fundamental to the outermost and hence to the word as a whole.

Alternately, the word may be mapped with the most specialized definition at the center. Thus, what is common or fundamental will be shifted to the periphery, and what is most specialized (what contains but exceeds the previous fundamental moments) will occupy the center.

Given that Hopkins defines a word in total as the "contraction or coinciding-point of its definitions," the second option seems to be what he has in mind (*Oxford Essays*, 306). Admittedly, this statement itself is not without complication, and partakes of Hopkins' habitual shiftiness where potentially opposite meanings are combined within a single term or phrase. If "coinciding-point" is interpreted to mean a common point within the definitions themselves -- as a point within each definition that coincides with a point in all other definitions -- then the core of a word should be regarded as the most basic denominator of all definitions. However, if the "coinciding-point" is interpreted to mean not a shared point in every definition but a single point that encompasses or contracts all aspects of each definition, then the core of a word should be regarded as the most complex and full definition possible, as containing all subsidiary or fundamental definitions within itself.

Since Hopkins defines the core not only as a "coinciding-point" but also as a contraction point, the second alternative is most appropriate to his description. Thus, the center contains everything that any of the peripheral definitions mean, and is a plenary summation of the word's total meaning. It follows from this that the peripheral definitions are fundamental to the core, and instances suggest particular knowledge of mechanics and engineering, and seem to rephrase an engineer's calculations as a poet's meter and imagery. One early example of such an instance occurs in a July 1865 fragment of *Richard*. Of a riverside meadow where the shepherds Richard and Sylvester feed their flocks and recite the romantic poets, the narrator describes

The grass was red
And long, the trees were colour'd, but the o'er-head,
Milky and dark, with an attuning stress
Controll'd them to a grey-green temperateness,
Making the shadow sweeter. (iv, 11-15)

Common sense makes sense of these lines easily – mixing any number of pigments typically results in a neutral grey-green color. Yet such a common sense reading makes no sense of Hopkins' word "stress." What does stress mean in the passage? What sort of stress is active in the colors of nature?

It is possible to account for stress in the poem in a Wordsworthian sense, as an idea in Nature or as a moral, intellectual, or metaphysical value expressed through Nature. While Hopkins was certainly a Wordsworthian poet in this sense (indeed, the poetic speaker equates the hues of light in the meadow with "temperateness"), and while his term stress would later acquire metaphysical import, it had not yet done so by the time he wrote this fragment of *Richard*. Hopkins composed fragments iii and iv of *Richard* in July of 1865 (Phillips 316 n49). During this time, as his journals attest, he struggled to find meaning in Nature and to articulate the patterns and forms he found there. But he had not yet coined his term stress to do so. His journals attest his quest for "laws" and structures and "shapes" and "inlaws" in the phenomena of nature,

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thus the core is built up from the periphery.

but his technical vocabulary of stress and instress is notably absent at this time, and does not appear until his "Notes on the Greek Philosophers" in 1868. Accordingly, Hopkins' later development of this term should not be superimposed on the present early instance of it.

"Attuning stress" raises other possibilities. Given that the "attuning stress" of the sky's milky darkness "controlls" the vegetation's greens and reds to a "grey-green temperateness," stress is a principle of harmony, and the various hues of light are analogous to musical tones in a chord. Properly speaking, however, stress stems not from musicology but metrics, and signifies the emphasis a syllable receives in speech. From this perspective, the opposing colors are analogous to opposing rhythms in a line of counterpointed poetry. Much as a counterpointed line of poetry consists of one rhythm laid over another, so the total effect of the light (grey-green temperateness) consists of the sky's somber hue laid over the vegetation's vibrant hue.

Stress also operates in a mechanical register, and another potential meaning of stress becomes clear if one interprets the various hues in the poem as vectors of force, and views the meadow's contrary colors much as an engineer might view the various pressures exerted upon an object. Viewed as such, Hopkins' language of stress recalls an engineer's calculation of a resultant of component forces. One of Hopkins' early notebooks from his schooldays at Highgate before Oxford summarizes a course of lectures in trigonometry and mechanics (*Oxford Essays*, 3). A page from this notebook shows Hopkins using a parallelogram of force to resolve component forces into a single resultant (page reproduced in Brown 217-18).[58]

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[58] "Component" and "resultant" are nineteenth century terms closely related to the modern word "vector." An object may be submitted to any number of component forces, each with varying strengths and pushing the object in differing directions. To calculate the net effect – the resultant -- of these component forces, an engineer cancels and simplifies the various components to determine a single quantity and direction of force active upon the object. Suppose, for example, that a 2000-lb. car traveling Northward at 45 mph crashes at an intersection into a 3000-lb. car travelling Westward at 30 mph. Such an example offers two component forces – a Northward-

In his undergraduate fragment of *Richard*, then, Hopkins does much the same that he did earlier in his schoolboy notebook, only instead of calculating the total effect of colliding forces, he calculates the total affect of colliding colors. Thus the vibrant hues of the red grass and the (presumably) green trees create one vector of bright color, and the “milky and dark” sky overhead creates another vector of somber color. The two vectors crash, and the resultant between vibrant red/green and somber milky darkness is “a grey-green temperateness.” Apparently, the somber vector of the sky is greater than the bright vector of the vegetation, since the former “controlls" the latter and the resulting “grey-green temperateness” of the total scene is closer to the sky’s component darkness than to the vegetation’s component brilliance. Much as an engineer determines the resultant of component forces within a structure or system, so Hopkins estimates the resultant mood derived by a human observer from the component hues within a scene.

Granted, the fact that stress in the *Richard* fragment may be explained as a musical or metrical term potentially obviates any mechanical application. Simply put, if the conventional metrical meaning of stress will make sense of the poem, why consider any unconventional or unexpected sense of the term? Thankfully, however, other instances of stress in Hopkins’ early poems and writings are expressly mechanical, and emphasize stress as synonymous with force. Considering the *Richard* fragment in tandem with these other writings suggests that even as early as 1865, stress was a rich, polysemic term for Hopkins, one that allowed him to consider the natural world of force and matter in terms consonant with music and poetry. In stress’

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moving component and a Westward-moving component – that are preserved in a larger system. Even after the crash, the two component forces are not annihilated, but continue to exert their force in combination. Accordingly, the direction and speed of the total mass of both cars after the crash is the result (or the resultant) of the combined force of both component forces. The crash does not destroy the component forces – both are operative in the behavior of the system after the crash.

simultaneously musical, metrical, and mechanical significations, the inner world of art could be reconciled to the outer world of nature.

Perhaps the clearest connection between stress and force occurs in Hopkins' poem "Oratio Patris Condren: O Jesu vivens in Maria" (1868?). In this poem, the speaker prays

> Jesu that dost in Mary dwell,
> Be in thy servants' hearts as well,
> In the spirit of thy holiness,
> In the fulness of thy force and stress (1-4)

As I will discuss in the next chapter, "fulness" is a theological term and suggests a metaphysical dimension for both force and stress, but the primarily material and mechanical meanings of these terms should not be overlooked. Here in this poem, Hopkins' parallel restatement of "force" as "stress" emphasizes the synonymous relationship between the two terms. Though "fulness" recasts stress in Christological terms, it does much the same for force. Thus, "fulness" transmutes two terms – two synonyms – that would otherwise express the mundane relations of matter and energy.

Other instances in Hopkins' writings, particularly those written during and after his Philosophate at Stonyhurst Seminary (1870-3), attest his equation of stress with force. Notably, Daniel Brown observes Hopkins' analysis of the behavior of bubbles and steam in his "Lenten chocolate" (*Journals* 203-4, Brown 209-10). As Brown describes, Hopkins watches his hot chocolate with curiosity, questioning why the vapor escapes the liquid in "throes" or in fits and sputters. Hopkins at length finds the answer: Bubbles consist of the same substance in two states, gaseous and liquid. The substance in the gaseous state forms the apparently hollow inside of the bubble, while the substance in the liquid state forms the "shell" or external "film" of the bubble.

The heated gas in the middle of the bubble expands as it heats and strains the liquid film of the bubble, but the film itself, as a liquid, has surface tension and resists the expansion of the gas. At some point, the "stress of heat" causing the bubble to expand overcomes the surface tension of the film (*Journals* 203). At this point, the film ruptures, the bubble bursts, and the gas trapped within forcibly escapes as vapor. Even though the "stress of heat" may be fairly uniform throughout the liquid, the surface tension of bubbles is not. Thus, bubbles burst at unpredictable and uneven rates. When a sufficient size or number of bubbles burst simultaneously, the amount of vapor released noticeably increases, making a sputtering effect as the vapor roils off the liquid in "throes."

In this Lenten meditation, Hopkins again uses stress as a synonym for force, more precisely the force of pressure. By "stress of heat," Hopkins refers to the pressure the expanding gas exerts against the film of the bubble. In this case, however, while the "stress of heat" is positionally located within the bubble, it is not expressive of the bubble's composition, neither does it preserve the bubble's integrity -- unlike the surface tension which preserves the film's coherence and which stems from the molecular properties of the liquid itself. The "stress of heat" stems from energy supplied by an external source, and should not be considered innate to the liquid. Thus, in this case the "stress of the heat" is an internal force in that it expands the bubble from within, but is not native to the liquid. In his description of the "stress of heat," then, Hopkins intends stress to denominate force pure and simple, separate from any vital or intrinsic correspondence to a particular object.

3.3.2 Springs, Wells, and Watches: Stress as Inherent Force

In another sense of the term, however, Hopkins frequently uses stress to denote not merely force, but force which inheres within material objects and natural phenomena. This usage appears particularly frequently in Hopkins' nature journals to describe the inherent quality of objects to endure strain and preserve proper shape and form. In moving from simple force to force as an inherent property of objects, this definition of stress comes nearer to Hopkins' conception of the core or composite meaning of the term. It also approaches Rankine's definition of stress as an active expression of elasticity by which an object resists external pressure and preserves its material form and shape.

Always attuned to the shape and curvature of nature's wonders, Hopkins often describes stress as the inner force (or "spring") by which an object resists external pressure and maintains its distinctive form. His usage is perhaps most striking when he describes stress as inadequate to the burden of external force. For example, in a March 12, 1870 journal entry, he describes "a heavy fall of snow" that "tufted and toed the firs and yews" (196). The snow accumulates on the boughs "and went on to load them till they were taxed beyond their spring" (196). Under the snow's weight, the boughs of the firs and yews droop unnaturally: the snow overcomes the trees' "spring" or internal stress, and alters the characteristic shape, set, or "scape" of their boughs.[59]

[59] Hopkins was deeply fascinated by the shapes of trees and boughs, and devoted much of his nature journal to classifying not only the characteristic shape of each species of tree, but the "inlaw" or "inscape" or inner principle of form responsible for a particular species' distinctive shape. See his discussion of the oak: *"Oaks: the organization of this tree is difficult. Speaking generally no doubt the determining planes are concentric, a system of brief contiguous and continuous tangents, whereas those of the cedar would roughly be called horizontals and those of the beech radiating but modified by droop and by a screw-set towards jutting points. But beyond this since the normal growth of the boughs is radiating and the leaves grow some way in there is of course a system of spoke-wise clubs of green --- sleeve-pieces. And since the end shoots curl and carry young and scanty leaf-stars these clubs are tapered, and I have seen also the pieces in profile with chiseled outlines, the blocks thus made detached and lessening towards the end. However the star knot is the chief thing: it is whorled, worked round, a little and this is what keeps up the illusion of the tree: the leaves are rounded inwards and figure out ball-knots. Oaks differ much, and much turns on the broadness of the leaf, the narrower giving the crisped and starry and Catherine-wheel forms, the broader the flat-pieced mailed or shard-covered ones, in which it is possible to see composition in dips etc on wider bases that the single knot or cluster. But I shall study them further"* (*Journals* 144-5).

While Hopkins does not expressly equate spring to stress in his description of the snow-laden firs and yews, he does associate the terms elsewhere. On a short Blandyke from St. Beuno's, Hopkins and a friend walked to Holywell to bathe in St. Winefred's Well.[60] Hopkins wrote in his journal,

> The sight of the water in the well as clear as glass, greenish like beryl or aquamarine, trembling at the surface with the force of the springs, and shaping out the five foils of the well quite drew and held my eyes to it. Within a month or six weeks from this (I think Fr. di Pietro said) a young man from Liverpool, Arthur Kent (?), was cured of rupture/ in the water. The strong unfailing flow of the water and the chain of cures from year to year all these centuries took hold on my mind with wonder at the bounty of God in one of his saints, the sensible thing so naturally and gracefully uttering the spiritual reason of its being (which is all in true keeping with the story of St. Winefred's death and recovery) and the spring in place leading back the thoughts by its spring in time to its spring in eternity: even now the stress and buoyancy and abundance of the water is before my eyes. (261)

"Spring" in this instance refers primarily to a fount of water, not an elastic force stored within an object under strain. Nevertheless, given Hopkins' theory of language, all definitions of a word build to a central core of meaning. A word's various definitions – and its various extensions – should consequently correspond, and often Hopkins invests the different senses or extensions of a word with complex patterns of meaning.[61] Spring is one such word, and whether

[60] "Blandyke" is a Jesuit term for a vacation.
[61] Hopkins actually went a bit further than this. Hopkins thought that not only did words have a stable core of meaning, but sounds or phonemes did as well. His early journals are full of

the word appears as a form of force, a wound coil of metal, or as a fountain of water, an underlying consistency informs each instance.[62] Namely, spring in Hopkins' writings uniformly suggests a pent inward force, one that often resists or is restrained by external pressure. Accordingly, Hopkins' "spring" is synonymous with stress in the Rankinian sense of an elastic force residing within an object.

Moreover, Hopkins consciously equates spring with force and stress. In the Holywell passage quoted above, Hopkins first intimates such a connection in his description of the surface of the water "trembling [. . .] with the force of the springs" (*Journals* 261). Granted, "springs" here literally means "fountains of water," but the underlying resonance of "pent force" appears in spring's proximity to "trembling" and "force." Likewise, later in the passage, Hopkins similarly associates springs with stress. The physical "spring in place" (the fountain of St. Winifred's Well itself) reminds Hopkins of the historical "spring in time" (the moment of St. Winefred's miraculous healing and resuscitation when the fountain first gushed forth), both of which flow from the divine "spring in eternity" (the Creator's eternal power and Godhead). The historical and divine springs are expressed by the physical spring, or as Hopkins puts it, "the sensible thing so naturally and gracefully [utters] the spiritual reason of its being" (261). In sum, Hopkins compounds all three springs in his closing formulation that "even now the stress and buoyancy and abundance of the water is before my eyes" (261).

Each of these three terms – stress, buoyancy, and abundance – applies equally to the "sensible thing" (the physical spring) and to the "spiritual reason of its being." Accordingly, "abundance" refers to the Creator's omniscient power displayed in Winefred's resurrection and

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speculations about the etymological and semantic connections between words derived from common phonetic roots. See for instance *Journals* 10-16.

[62] Pertaining to spring at least, Hopkins' theory of language makes good common sense. Most things that share the name of "spring" share a common nature and behavior – springs spring.

in the “chain of miracles” since, as well as to the plentiful waters of the spring. Likewise, “buoyancy” describes the river of God’s grace throughout time, from its fountainhead in eternity to its manifold instantiations in human history, as well as the physical waters of the fountain.[63] And finally, stress applies both to the metaphysical force of God’s grace, as well as to the physical force inherent within the spring of water. Much as the “sensible thing” utters the “spiritual reason of its being,” so the physical force of the fountain points to the eternal power that brought it into being.

In fine, both stress and spring articulate a physical force capable of metaphysical extension. Much as in “Oratio Patris Condren,” when force and stress were transmuted by “fulness,” so spring and stress are transmuted here in Hopkins’ journal. But like force and stress in Father Condren’s prayer, spring and stress in this description of Winefred’s Well are initially material, and describe a physical force inherent within the fountain. The sequence of the journal entry itself should be noted: Hopkins first notices the “force of the springs” that makes the water “[tremble] at its surface,” and this physical power “leads back [his] thoughts” to the eternal power from which all power stems.

Beside representing a physical force, Hopkins’ springs also suggest an internal force by which an object preserves its shape. As mentioned above, the “spring” of the firs and yews offset (albeit unsuccessfully) the weight of the snow on their branches. Others of Hopkins’ springs behave similarly. In his sermons, Hopkins employs a watch spring to illustrate the motive force of sin within human nature:

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[63] Hopkins’ rivers tend to flow in space and through time equally. Readers may remember from the *Wreck of the Deutschland* that “it” “rides time like riding a river,” and, “dat[ing] from day of his going in Galilee [. . .] is in high flood yet.”

> Everybody feels at least *some* inclination to heat of temper, to gluttony or drunkenness, to impurity, to love of money, and so on, one or all of these things, and more or less they fall into them, some more, some less. But if God by a special grace were ever to have kept anyone, as perhaps he may have kept St. John Baptist, from falling into any the least sin, still such a man would have the inclination to sin left though he did not yield to that inclination: a watch wound up but kept from going has the spring always on the strain though no motion comes of it. Such a mainspring of evil in us is the concupiscence that comes in with original sin and lasts even when original sin has been taken away by baptism. (*Sermons* 44)

While the impetus to sin is a metaphysical quality, the image Hopkins selects to express it – the watchspring – is manifestly physical, as is the stress which the spring stores in its coils. The watch spring attests the inner and intrinsic nature of sin, reproducing in physical terms what sin works psychologically and metaphysically. Much as the stress of a spring is stored internally within its coils, so the impetus to sin is pent within the heart. Additionally, both watch-spring and sinful nature express an inherent force opposed to external pressure that preserves an intrinsic shape or "bent." Sinful nature rebels against social, religious, and personal inhibitions to exhibit the malformed "shape" of the heart, and a watch spring reacts against the force that wound it to recover its wonted unwound shape. The ticking of a watch illustrates the spring's action in unwinding itself to regain its customary shape.

Like his sin nature sermon, Hopkins' curtal sonnet "To His Watch" also works by a similarly metaphorical extrapolation of the stress of a coiled spring. Hopkins compares his heart to his watch, noting that both will eventually "fail at our force" (3) Given that the "force" of a watch stems from its spring – wound and under stress -- once more Hopkins uses the spring as an image connoting stress and physical force to recover proper form. In applying force to recover form, Hopkins' watch-springs correspond to the "spring" of the fir and yew trees in reproducing Rankine's definition of stress as an internal force which "consists in a tendency of the body to recover its natural state" after having been strained out of shape (*Miscellaneous,*74). Both springs, mechanical and arboreal, suggest an elastic force expressive of an essential organization of parts that resists strain and seeks to recover proper shape.

Other passages from Hopkins' journals also illustrate the congruence of Hopkins' with Rankine's stress. At one point in his journals Hopkins describes an especially frightening instance of waking sleep paralysis. Hopkins narrates the experience in terms that recall a succubus, recalling that "I thought something or someone leapt onto me and held me quite fast." Awakened by the sensation, Hopkins finds that his mind and senses are alert, but -- to his horror -- his body remains paralyzed by sleep. He likens his fright to waking mid-fall, "as when one is very tired and holding oneself at stress not to sleep yet/ suddenly goes slack and seems to fall and wakes." But unlike a person who wakes mid-fall, Hopkins, although he regains conscious sensation, does not regain muscular control. He records that "I had lost all muscular stress [. . .] but not sensitive, feeling where each limb lay" (238). While Hopkins can feel, he is unable to move or exert muscular force. In the absence of the "muscular stress" that tensions the body's bulk, Hopkins feels his body crush under the gravitational force of its own inert mass: "The feeling was terrible: the body no longer swayed as a piece by the nervous and muscular instress seems to fall in and hang like a dead weight on the chest" (238). Without the intrinsic and proper stress of his muscles, his body loses its coordinated unity (it is "no longer swayed as a piece"), and collapses inward under gravitational pressure.

As with his treatment of springs, Hopkins discusses "muscular stress" in this passage as an inherent pressure that maintains the body's shape against external gravitational force. Without the internal stress the muscles provide, the prone corpse "fall[s] in" and "hang[s] like dead weight" on the ribcage. Much the same conception of stress appears in another passage where Hopkins recollects watching the ebb and surge of the sea from a cliff in the Isle of Man. While the context of his observation (a cliff overlooking the sea) differs completely from those discussed previously, his vocabulary and meaning remain consistent. Hopkins writes, "I noticed from the cliff how the sea foots or toes the shore and the inlets, now with a push and flow, now slacking, returning to stress and pulling back" (221). As in his description of sleep paralysis, when the sea "slacks" its stress, it "falls in" or "pull[s] back" down the shore, but in "returning to stress," it resurges to the extent of its shape and bounds.[64] Repeatedly, whether describing a tree, a well, a watch, a body, or a wave, Hopkins treats stress as an intrinsic force preserving an object's shape. Hopkins' imagery of stress closely resembles Rankine's definition of it: "the force [. . .] which [an object] exerts in tending to recover its free condition, and which, for a state of equilibrium, is equal and opposite to the combination of external forces applied to it" (*Misc.*, 120).

3.3.3 Slack Ropes and Dis-stressed Selves: Stress as Force of Formal Unity

Moving still closer to Hopkins' core understanding of stress, the poet uses the term not only to describe the inner force preserving an object's shape, but the inner force by which an object consists. In this, Hopkins' usage realizes the full extent of Robison, Gregory, Barlow, and

[64] It may seem odd to think of a body of water having a "shape," but Hopkins consistently describes the sea (and water or fluid in general – see below) in terms of its bounds, limits, or foredrawing. See the first stanza of the *Wreck of the Deutschland*, where Hopkins likens God's mastery in shaping the sea to his creative act of shaping the human frame. As "World's strand," God gives the sea its shape or bounds, and as Creator of the human form, God gives the poetic speaker his bodily shape and bounds as well.

Rankine's strength/stress. As the engineers defined strength/stress as an active force expressing and preserving an object's structural coherence, so Hopkins treats stress as a vital force indicative of the distinct character of natural phenomena, living organisms, and even human beings. Yet in realizing the extent of the engineer's term, Hopkins also surpasses it. In characterizing stress as the vital force of living organisms and human beings, Hopkins' term leaves the realm of the strictly mechanical and ventures into psychology and metaphysics. All the same, though Hopkins' usage does eclipse the engineers', it nevertheless stems from a mechanical and physical grounding of the word.

As in his observations of the yew and fir trees, his sleep paralysis, and the waves below the cliff, Hopkins often describes the force of stress in abeyance or "slackening." This trait recurs in his poems "The Times are Nightfall," "Spelt from Sybil's Leaves," "Carrion Comfort," and in his commentary to St. Ignatius' "A Meditation on Hell."[65] Norman MacKenzie compares the sonnet fragment "The Times are Nightfall" to Hopkins' "extraordinarily weighty" sonnet "Spelt from Sibyl's Leaves," observing that the "opening imagery" of the poems matches closely (157, 228). Indeed, in both poems, light wanes in the world and darkness encroaches. "Nightfall" tells of a "world undone," where the "light grows less," while "Sibyl's Leaves" similarly claims "for earth her being has unbound" and warns "our evening is over us, our night whelms, whelms, and will end us" ("Nightfall" 1, 2; "Sibyl's Leaves" 5, 8). Additionally, the poems correspond in sequence and structure, moving from an initial exposition of cosmic apocalypse to the doom of particular living creatures, and closing with a cautionary moral. Beyond these similarities,

[65] "The Times Are Nightfall" is an unfinished sonnet, likely composed in 1886 (MacKenzie, *Readers Guide*, 228). "Carrion Comfort" is usually regarded as one of what Robert Bridges called Hopkins' "terrible sonnets," or what critics often refer to as the "sonnets of desolation," most likely composed between 1885 and 1886. Likewise, Hopkins sent "Spelt from Sybil's Leaves" to Robert Bridges in a letter dated 11 December 1886. Given the proximity of their composition, similarities between these poems are not surprising.

however, both poems concern the loss of individually distinguishing form, or the unique coherence or pattern – the stress – by which a living being exists.

"Sibyl's Leaves," in describing the apocalyptic extinction and obliteration of life ("self in self steeped and pashed – quite disremembering, dismembering all now") presumably speaks of the annihilation of human life during the Last Days, but also enfolds the flora and fauna of Nature in the doom of the world. "Nightfall," however, speaks particularly of "man's distress." Given the apocalyptic imagery elsewhere in these two poems, "distress" should be taken as a Spenserian pun, or as "dis-stress." Much as the play of earthly life – earth's "dapple" – is "at end" in the apocalyptic vision of "Spelt from Sibyl's Leaves," so human life is "dis-stressed" at the "Nightfall" of the world. In the context of these two poems, "dis-stress" not only connotes loss of being or loss of life, it also signifies the loss of personal distinctiveness or particular individuality. In "Sibyl's Leaves," the heterogenous dapple of life is reduced to just two "skeins" or "spools": "black, white" or "right, wrong."[66] In the apocalypse the Sybil foresees, and more so in the *Dies Irae* following the apocalypse, individual beings lose their fine distinctions and become indistinguishable: they are "pashed" together, and earth's scintillating dapple is "all throughther."[67] The beauty and form and variety of Nature are irrelevant in the Last Day, and all that matters is God's assortment of his creatures upon the two spools of "right, wrong."

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[66] Hopkins often uses thread-like imagery of skeins, ropes, and strands to speak of the self-distinctive action of a creature indicative of its essential nature. Thus, the world is a welter of various skeins or strands of being. In the judgment following the apocalypse, however, the welter or dapple of life is viewed in "black, white," and the various "skeins" of being are "wound" onto two spools. Presumably, one spool represents the just, while the other represents the damned. The fact that these two "spools" of being are also likened to two "flocks" or "folds" recalls the biblical judgment of the sheep and the goats.

[67] "Throughther" is a dialect word, a portmanteau of "through" and "other." Distinct shapes are muddled and confused, and each is *blent*, in a Spenserian sense, with others. Thus, an observer sees one thing "through other," or inextricably pashed and melded with other forms.

Most likely, this dissolution of self-distinction stems from two competing causes, both the violence of the apocalypse itself and the moral judgment of God in the *Dies Irae.* MacKenzie sees the sonnet describing “the last evening before Chaos takes total repossession of the earth” (158). Thus, while God at creation formed the multivariate phenomena of Nature, in the final dissolution of the world the various shapes within Nature return to Chaos, or to their amorphous, pre-formed state. Thus, the “pashing” and “throughthering” of the sonnet, in one sense, describe earthly things as they lose their individuation, melt together, and commingle in Chaos. In another sense, however, the loss of individuation results from God’s moral judgment of the earth’s dapple, in which the manifold forms of Nature are reduced to the “black, white” categories of “right, wrong.” Readers should remember that the sonnet’s title stems from a line in a requiem hymn: “That day of wrath [. . .] to which David and the Sibyl bear testimony.” Much as the requiem hymn merges Classical and Judeo-Christian sources, so the sonnet merges classical and Christian versions of the apocalypse. As such, the octave of the sonnet describes the world returning to a classical Greek Chaos, while the sestet describes the world undergoing a Judeo-Christian judgment. The fact that the classical and Christian versions of doom are incompatible generates part of the tension between the octave and sestet. But the versions of doom agree in that, whether through physical dissolution or moral judgment, the variety of the natural world is depleted and reduced. In both the Greek octave and the Christian sestet, the things of this earth grow strangely dim, losing their distinctive shape and identity either physically -- to Chaos -- or morally -- to God’s absolute judgment.

Taken together, both parts of the long sonnet are concerned with the loss of a thing’s distinctive, particular form. Given that “Nightfall” partakes of similar imagery as “Sibyl’s Leaves,” it seems reasonable to consider the “dis-stressing” of “man” in “Nightfall” as resembling the “pashing” and “throughthering” and “disremembering, dismembering” of natural phenomena in “Sibyl’s Leaves.” Thus, distress or dis-stress connotes losing one’s distinctive form, or losing the active force of stress that preserves one’s individuality and integral identity.

In the apocalypse, this loss of vital stress occurs in the tumult of the end times, as the phenomena of the world decompose to the warring elements of Chaos, or in the judgment on the Day of Wrath, as one’s personality or selfhood is submitted to God’s rigid rubric of Right versus Wrong. In the first instance, stress is quite physical, and closely duplicates Rankine’s, Barlow’s, Robison’s, and Gregory’s usages in that it represents a quantity of force binding the particles of an object together in a stable and cohesive form. In the second instance, however, stress functions as a psychological force, and preserves the psychological unity of a person. Given that Hopkins wrote both “The Times Are Nightfall” and “Spelt from Siby’s Leaves” in a time of abject depression and despair in Dublin, this psychological meaning of “distress” should be considered as primarily operative in the poem. However, the psychological is underwritten by the physical, and the meaning of distress as to lose psychological unity is founded on the meaning of distress as to lose physical coherence.

The psychological and physical extensions of stress – or rather, of stress’ absence – similarly vie with each other in Hopkins’ “terrible” sonnet “Carrion Comfort.” In this sonnet, the word “stress” never appears, but its direct antonym “slack” does. “Slack” and “stress” are paired opposites in Hopkins’ personal vocabulary, and the presence of the one calls the other to mind, even in emphasizing its absence. Most likely, Hopkins derived his pairing from poetic scansion, with its various systems and patterns of stressed and slack syllables.[68] But Hopkins’ customary

[68] Critical discussion of Hopkins’ poetics supports a particularly robust conversation about his metrical theories, as is appropriate given that Hopkins was a daringly experimental poet. Hopkins’ innovation of sprung rhythm is probably his most well-known and widely-discussed

pairing of the terms extends beyond scansion, and, as Hopkins' journals, letters, and poems attest, the two terms systematically function as direct antonyms when Hopkins discusses either physical force or psychological unity, as well as when he discusses poetry. As we have seen previously, Hopkins contrasts the two words in the preliminary discussion of his account of waking sleep paralysis: despite one's effort to "hold oneself at stress not to sleep," one "suddenly goes slack and seems to fall" (Journals 238). Likewise, as we also have seen above, Hopkins contrasts the terms in his description of the sea's alternate "slacking" and "returning to stress" (Journals 221).

While in these examples, both terms appear on the page in sharp opposition, in other passages of Hopkins' writing, slack emphasizes stress's absence both on the page itself and in the object being described. When, for instance, Hopkins describes a waterfall in the Alps, he records that "in one place over a smooth table of rock came slipping down a blade of water looking like and as evenly crisped as fruitnets let drop and falling slack" (Journals 178). Nowhere in this passage does Hopkins use the term "stress," but his description of the fruitnet recalls the ropes, braids, bands, bonds, bounds, lace, lashes, lanyards, coils, strings, strands, webs, and all other things threadlike, single and woven, that wind through Hopkins' works. Typically, Hopkins' rope imagery is described in terms of its stress or strain.[69] The fruitnet in this instance poses no exception – while it "fall[s] slack," its slackness is a measure of its stress, or rather the lack of it.

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experiment. While sprung rhythm is outside the scope of this paper, please see my brief sketch, above, of critical appraisals of Hopkins' metrical "stress".

[69] The most frequently discussed examples of Hopkins' ropes occur in his shipwreck poems, *The Wreck of the Deutschland* and *The Loss of the Eurydice.* Both poems feature rope-like images under stress and strain (e.g. "But roped with, always, [. . .] a pressure" or "he is strung to duty, is strained to beauty"). The fact that a rope's primary function is to exert stress or to endure strain suggests that Hopkins' fascination with rope imagery stems from his desire to represent stress and strain.

Hopkins' writings feature several other instances of slack ropes. One of the most interesting of these passages describes "a strong shadow [that] lay in a slack between two brows of Pendle" (*Journals* 210). In one sense, the description implies an earthen rope: the "slack" earth sags between the two higher, stressed brows. The description also suggests a line of poetry – the earth-line falls in the slack and rises in the stress. As elsewhere in his writings, Hopkins in this passage seems to be trying to resuscitate the ossified metaphors of common speech.[70] Here, by mixing poetic and topographical terminology, he seems to be trying to recoup the rope imagery embedded in poetry ("a line of poetry") as well as in topography ("earth-line," "sky-line"). Thus, Hopkins imagines mountains as lines of poetry, and the falling and rising syllables of poetry as valleys and crags of mountains. But beneath that, he sees both poems and topographical features as waving, oscillating ropes -- lines of force responding to varying degrees of slack and stress.

Yet another slack rope appears in "Carrion Comfort," one that simultaneously signifies slackness of both physical and psychological stress. The first four lines of the sonnet are addressed to Despair, one of Spenser's psychomachic villains from the *Faerie Queene.* Both Hopkins and Spenser associate Despair with death and carrion. The face of Spenser's monster is essentially a death's head, with his "deadly dull" eyes and his skeletal, "raw-bone Cheeks, [which] through Penury and Pine,/ Were shrunk into his Jaws, as he did never dine" (1.9.xx-xx). Likewise, Despair lives in a veritable charnel house amidst the bodies of the knights he has convinced to commit self-slaughter: he "his dwelling has, low in an hollow Cave [. . .] like a Greedy grave, that still for carrion Carcases doth crave" (1.9.xx-xx). Furthermore, the final lines

[70] Compare, in Hopkins' sermons and in the poem "Felix Randal," his use of the Lancashire phrases "in this road," "any road," and "all road" for the more typical phrases "in this way," "any way," and "all ways" (*Sermons* 47, 73). By following the Lancashire people in replacing "way" with "road," Hopkins restores the spent metaphor to its original vitality.

of Spenser's canto suggest that Despair is himself undead carrion. When the Redcross Knight at last, at Una's reproof, spurns Despair's deathly counsel, Despair hangs himself, "But Death he could not work himself thereby/ For thousand times he so himself had dress'd,/ Yet natheless it could not do him die" (1.9.xx-xx).

Hopkins' Despair also appears as a carrion corpse with a mordantly bewitching offer. While Spenser's Despair tempts Christian knights to commit suicide, Hopkins' Despair, in addition to suicide, tempts the poem's speaker to wallow in misery, or to feed on death by "feasting" on Despair's undead corpse. The opening line of the poem announces the speaker's refusal: "Not, I'll not, carrion comfort, Despair, not feast on thee." The temptation Despair offers is to submit passively, to acquiesce to one's misery, and to derive bitter comfort from the delusion that one has done all one can do. Against this temptation, the speaker resolves "I'll not [. . .] cry *I can no more*. I can;/ Can something, hope, wish day come, not choose not to be." Yet despite the speaker's heartening resolution, the sequence of "hope, wish day come, not choose not to be" is unsettling. In searching for the "something" he can do, the speaker at first considers that he can at least hope. Presumably, he hopes for relief and future joy. The next phrase, "wish day come" tempers this, however – the speaker hopes not for future joy but merely for the dawn of the next day. Even this is tempered in the final phrase "not choose not to be." In this phrase, the speaker appears almost completely inert once again, not hoping, not wishing for dawn, not seeking to improve his condition, but merely refusing to choose death.

In a word, Despair tempts the speaker to be "slack," to give over the struggle for hope and to acquiesce to grief and even death. Appropriately, the first quatrain of the sonnet's octave features yet another of Hopkins' slack ropes. Immediately after vowing not to feast on Despair, the speaker asserts that he will "Not untwist – slack they may be – these last strands of man in me." Although his inner "strands of man" are slack already, the speaker pledges not to make them slacker still, or to willingly cooperate with the dolor that oppresses him.

While Hopkins' "strands of man" are admittedly metaphorical, they suggest a physical basis for the psychological "slack" in the poem. In the terms of the poem's metaphor, Hopkins likens his psychological state to a physical body, one whose stability and coherence is assured by strings or ropes that pass between his members and lace his body together.[71] If poems and mountains are oscillating ropes, so is the human body, and the human ropes respond to slack and stress as do the other strands of Nature. In "Carrion Comfort," slack ropes suggest a weakened body, one threatened with dissevering and pulling apart. Stressed ropes or strands, on the other hand, suggest a strong and robust body, one that can withstand the pressures and strains exerted upon it.

While Hopkins' usage is metaphorical here, and the physical imagery of slack ropes represents a psychological state, the physical imagery nevertheless suggests an understanding of stress closely akin to Rankine's. For Rankine and his engineering forebears, strength/stress preserved the integral unity of an object from external assaults upon it. Similarly, in Hopkins, slackness corresponds to a lack of stress and leads to personal disintegration – physically, and by metaphorical extension, morally and psychologically. If "stress" is an internal force that preserves individual identity and being, then slack represents the decomposition of this force. Once again, "Carrion Comfort" depicts stress as a vital tension without which the integrity of the

[71] Again, Hopkins is revitalizing old idioms – "heartstrings," "fiber of [my] being," "strands of [my] being," etc. Hopkins typically revitalizes idioms by taking them at face value, and reawakening his audience to the concrete materiality of the objects and images within the idiom. See footnote 36, above, concerning Hopkins' revitalization of the expression "any way." In order to restore English metaphors to their originary force, Hopkins de-familiarizes their imagery, forcing readers to consider the metaphor afresh and to discover the concrete expressions underlying them.

object/person decomposes. Importantly, the psychological and moral value of stress/slack is underwritten by a physical understanding of the binary pairing, and is accompanied by a network of physical imagery –ropes, strands, webs, threads, nets, etc. Although the "slackness" of Despair figures primarily in moral and psychological relationships in the sonnet, these relationships extend from an originary physical sense of stress/slack. Thus, the physical sense of the "strands of man" within the speaker, while metaphorical, are also originary, and the moral and psychological extensions of these terms derive from the physical.

3.3.4 Flushing and Foredrawing: Stress as Ontology

Stress also accrues ontological signification in Hopkins' writings, as perhaps best seen in his notes on Parmenides and in his commentary on the Ignatian exercise "A Meditation on Hell." As I have remarked earlier, Hopkins' term stress should be regarded more as a matrix of meaning – or rather a root word with broad-ranging definitions and extensions -- instead of as a single, discrete term. Accordingly, in his exposition of Parmenides, Hopkins explores the metaphysical resonance of stress, and in his commentary on Ignatius' "A Meditation on Hell" he abuts several senses of stress together. Among the other meanings of stress in his commentary on hell, at points Hopkins equates stress with the "energy [. . .] with which the soul animates [. . .] the body" or the "energy of the whole being" (*Sermons*, 138). Much as the psychological import of stress in "Carrion Comfort," "The Times Are Nightfall," and "Spelt from Sybil's Leaves" derives from physical imagery and a physical understanding of stress, so the various metaphysical energies of stress in Hopkins' "Parmenides" and his commentary on hell stem from an underlying conception of stress as physical force. Physical and metaphysical definitions of the term contract and coincide at the term's core, and the physical basis of stress is preserved as a moment within Hopkins' central and metaphysical definition of the term.

The classical philosopher Parmenides was, like Xenophanes and the Pythagoreans, simultaneously a skeptic and a seer. Parmenides mistrusted the physical senses on the ground that one object can appear differently to different people.[72] But while he mistrusted sensation, he trusted reason, which he believed to be entirely separable from sensory perception. Through rational argument, Parmenides demonstrated that Being exists in a total or universal sense.[73] Yet because he mistrusted the senses, he strongly doubted whether any particular instance of Being (an object that can be seen with the eyes, felt with the hands, tasted by the tongue, etc.) exists as it appears to the senses.

In his philosophical hymn to Being, Parmenides accordingly holds that Being is one and indivisible. The hymn, entitled *On Nature*, divides in two after an introductory proem. The first section, *Aletheia* or "The Way of Truth," teaches that the "Many" – the objects we perceive with our senses – do not exist in truth but only to our sensuous perceptions. Being, then, should not be perceived as divided into separable objects, but should be conceived as it truly is: indivisible, universal, and single. However, the second section – *Doxa* or "The Way of Opinion" – summarizes the way people typically perceive Being. In this section, Parmenides describes individual objects in a way he forbade in the *Aletheia*, as not only separable and individual themselves, but as composed of the elements of fire and night/earth.

Contention persists in reconciling *Aletheia* to *Doxa*. Essentially, if *Doxa* is false, why did Parmenides afford it such interest? As well, if individuated being is illusory, why should Parmenides devise his own cosmogony in which the world, and all objects within it, form from

[72] Drunkards, the sick, and the insane perceive objects differently than a human being in his or her normal state. It may be argued that this recommends the perception of a healthy human being as accurate. Parmenides disagreed, though, perceiving all human beings as inebriated or feverish. Thus, reality is a collective hallucination.
[73] Parmenides' Being was not abstract but concrete. In other words, Parmenides did not conceive of Being as immaterial or estranged from matter.

fire and night/earth? Scholars have variously attempted to reconcile the two sections.[74] Hopkins, at least, under the Germanic – particularly Hegelian – influence of his Oxford professors and tutors Benjamin Jowett, T.H. Green, and Walter Pater, sublates the negation between monist, universal Being and the several, particular Many. Thus, each instance of the Many is a particularization of universal Being. In Hopkins' words, "the phenomenal world [. . .] is the brink, limbus, lapping, run-and-mingle / of two principles which meet in in the scape of everything --- probably Being, under its modification or siding of particular oneness or Being, and Not-being, under its siding of the Many. The two may be called two degrees of siding in the scale of Being" (*Oxford Essays* 316).[75] As Daniel Brown writes, "Hopkins believes that the Parmenidean fragments sustain his view that ultimate Being is comprised of numerous discrete instances" (Brown 175). In Hopkins' interpretation, Parmenides teaches that metaphysical Being expresses itself in the objects of the physical world.

Hopkins structures his response to Parmenides according to the philosopher's own categories of transcendent Truth (*Aletheia*) and Opinion or sensuous perception (*Doxa*). Pertaining to the first, Hopkins addresses metaphysical Being or God; pertaining to the second, Hopkins addresses phenomenology or observed reality. For both categories, however, Hopkins applies his coinages "flush" and "foredrawn." Aspects of stress – or more precisely of instress –

[74] Efforts are complicated by the fact that Parmenides' poem exists in fragments, some of which are missing, and by the fact that Parmenides himself is a slippery dialectical thinker.

[75] Hopkins' subdivision of Being is a little unwieldy. He divides Being into two "sidings," Being and Not-being. On the one hand, Hopkins creates the apparently tautological claim that Being is a subdivision of Being. On the other hand, Hopkins creates the apparently contradictory claim that Not-being is a subdivision of Being. What Hopkins means by this is that Being, in total, exists in two guises, a universal guise and a particular guise. The universal guise Hopkins names Being, and the particular guise Hopkins names Not-being. (After all, what is particular is not universal. If universality is Being, then what is particular is not Being, or Not-being. In this case, "Not-being" does not imply non-existence, but merely non-universality.) Accordingly, Being exists as Being (universality) and Not-being (particularity). Please see below for a fuller explanation of the universal (one) and particular (individuated) aspects of being.

the flush and the foredrawn adapt the language of mechanical force to illustrate the nature of Being, both noumenal and phenomenological. In so doing, these coinages reinforce the analogy between the Being and matter, and employ forces constitutive of material objects as metaphors to characterize ultimate Being – God himself.

Daniel Brown articulates the relationship between stress, instress, flushing, and foredrawing. According to Brown, "stress is synonymous with Being,"[76] and "instress is an instance of such being to which belongs, as the prefix indicates, an internal or intrinsic principle of unity" (Brown 175). Furthermore, as Brown observes, Hopkins defines instress as a composite unity of two opposing forces, flushing and foredrawing: "[Parmenides'] feeling for instress, for the flush and the foredrawn, [. . .] is most striking" (*Oxford Essays,* 311). According to Brown, flushing is a "principle of motion" or "dynamic liquidity" characteristic of thin, runny fluids like water (171, 173). Contrarily, foredrawing "focuses upon the bounding definition in which such force draws together as a unity," and is characteristic of more viscous fluids like oil (174). To rephrase, flushing is a property of things to lose individual distinction and to flow together, much as two droplets of water may come together and merge as one. Foredrawing, on the other hand, is the capacity for objects to maintain individuation. Hopkins often represents foredrawing as the surface tension of a liquid, especially evident in such viscous liquids such as oil. Thanks to its surface tension, a drop of oil will bead or form a spherical globule rather than bursting its meniscus and running flat across a surface. Likewise, when two globules of a sufficiently viscous liquid meet, although they may touch they will not merge.

[76] Elsewhere, as I do, Brown links stress to energy and force. In associating stress with Being, Brown does not contradict himself, however. As Brown proceeds to explain, Hopkins himself describes Being in the language of force.

Brown observes a characteristic instance of Hopkins' flush/foredrawn binary in an August 30, 1868 journal entry:

> I saw the phenomenon of the sheepflock on the downs again from Croham Hurst. It ran like the water-packets on a leaf – that collectively, but a number of globules so filmed over that they would not flush together is the exacter comparison: at a gap in the hedge they were huddled and shaking open as they passed outwards they behaved as the drops would do (or a handful of shot) in reaching the brow of a rising and running over.

Here, Hopkins compares a sheepflock to drops of water running on a leaf. As Norman MacKenzie explains, just as droplets merge and join in flowing, the sheep from the distance of Croham Hurst appear to lose their individual distinctions and run across the downs like a single rivulet of sheepwater (MacKenzie, *Readers Guide*). Yet despite the illusion created by Hopkins' distanced perception, he understands that the sheep, unlike water droplets, retain their individuation. Accordingly, Hopkins refers to them not as droplets but "water-packets," or as "globules so filmed over that they would not flush together." The sheep are sharply foredrawn, and their proximity cannot overcome their "viscous" selving. Hopkins ultimately compares them not to droplets or globules of fluid, but to spherical solids -- "a handful of shot." Like a fluid, the sheep-shot flow together across the downs, dam up as they pass through a gap in a hedge, and then pour out of the gap to flow over a ridge. But unlike a fluid, the sheep maintain their selving and remain individuated.

In naming the force by which a fluid coheres or the force by which a fluid disperses, foredrawing and flushing designate physical properties of liquids, and describe the various operations of force within a liquid medium. Accordingly, the terms correspond to hydrodynamics. Yet through metaphorical extension, Hopkins adapts his terms to phenomenology, likening fluid mechanics to the mechanics of human perception. In phenomenological terms, flush, given its associations with fluidity and unity, speaks to the correspondence between objects, or an object's propensity to resemble another object. Thus, objects are flushed by the characteristics they share with other objects, particularly those universal characteristics or mental categories in which they partake (e.g. -- all red objects partake of the universal category of redness; all sharp objects partake of the mental category of sharpness; etc). Accordingly, "flushness" unites disparate objects and tends to express the unity and universality of Being. Contrarily, foredrawing "denotes [an object's] specificity as a differentiated unity, a concrete particular" (Brown 174). While the characteristics of an object may be common, the particular collection of characteristics may be unique to that object. A red pen, for example, shares its color with other red objects, and its cylindrical shape with other cylinders. It also may share its material composition with other composite plastic-metal objects. But in its collection of characteristics as a red cylindrical plastic-metal object, it comes closer to individual distinction. As well, even though some mass-produced objects may be identical to others of their kind, each is unique in that it is *this* object and not another – this red pen or that red pen and not any other red pen. Much as flushness is a principle of unity, then, foredrawing is a principle of individuation, and expresses the distinction of concrete particulars. All objects or selves partake of flushing and foredrawing alike: all objects share universal characteristics with others, but possess their own distinct being nevertheless.[77]

[77] In phenomenological terms, Hopkins schema of "flush" and "foredrawn" may be compared to Hegel's chapter "Sense Certainty" from his *Phenomenology of Spirit*. In this chapter, Hegel argues that all objects are discrete complexes of universals. Every object is informed by multiple universals, and receives its particular nature from the unique combination of universals it contains. Hegel's description of the universal characteristics that an object shares with other

As phenomenological terms, flush and foredrawing figure prominently in Hopkins' commentary on Parmenides' *Doxa*, or his analysis of sense perception:

> For the phenomenal world (and the distinction between men or subjects and the things without is unimportant in Parmenides: the contrast is between the one and the many) is the brink, limbus, lapping, run-and-mingle / of two principles which meet in the scape of everything – probably Being, under its modification or siding of particular oneness or being, and Not-being, under its siding of the Many. Foreshortening and equivalency will explain all possible difference. The inscape will be the proportion of the mixture. (*Oxford Essays*, 317)

Hopkins' description here applies "for the phenomenal world," or for the world as perceived by the senses, not the noumenal or metaphysical realm of absolute Truth or Being. Sensuous perception of an object (perceiving the "scape of [a thing]") occurs as the result of two principles: one principle by which the "particular oneness" of Being is perceived in the scape of the thing, and another principle by which the individuated "Many" are perceived in the scape of the thing.[78] Given that flushing connotes oneness, and foredrawing connotes individuation, the present account of sensation repeats Hopkins' formulation that "all things [. . .] are meaningless without [. . .] instress, the flush and the foredrawn" (311). Without the categories of flushing and foredrawing, all things are meaningless to human perception, or human perception itself is meaningless.

Hopkins further clarifies the operations of flushing and foredrawing in another passage in his "Parmenides" notes. Without stress, or the opposed principles of flushing and foredrawing,

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objects may be compared to Hopkins' "flushing"; the discrete unity of the object as a complex of its universals is analogous to Hopkins' "foredrawing."

[78] I discuss scape in the next chapter. For now, I will define scape as the perceived image of a thing.

"there would be no bridge, no stem of stress to carry the mind over: without stress we might not and could not say / Blood is red / but only / This blood is red / or / The last blood I saw was red / nor even that, for in later language not only universals would not be true but the copula wd. break down in particular judgments" (313).[79] Without flushing, the ability to perceive the universal common to particular instances, an observer could not reason inductively to define a thing by its instances. Specifically, an observer could not, by examining various instances of blood, perceive that all instances of blood are red, and thus induce that Blood must be red. Likewise, without foredrawing, the ability to perceive the particular object in the matrix of the universals that compose it, no recognition of particular being would be possible. Without foredrawing, one might be able to see the qualities of redness and fluidness at large in the world, but one would not be able to see these qualities combined in a particular object, or would not be able to see the red fluid itself.

Hopkins' hydrodynamic phenomenology begins to explain instress -- that term so critical to his poetics -- as well as his metaphysical sense of stress. Through stress, or the instress of a particular thing, Hopkins can generalize from the specific object to universal Being, or alternately, can see universal Being in the specific object. Thus, when Hopkins claims to have "felt the depth of an instress or how fast the inscape holds a thing," he means that he has perceived how the foredrawn, particular object corresponds with the universal Being that flushes it (313). In simple terms, he claims to have found a transcendent quality in the object of his perception.

[79] Hopkins uses the word "stress" here, but Brown's point should be remembered that "instress is an instance of [stress]" (Brown 175). Accordingly, Hopkins means stress as general term to express collective instress.

Yet while stress in this sense extends from phenomenology to metaphysical Being, the prior moment of physical force should not be overlooked. In describing the behavior of fluid bodies, flushing and foredrawing apply a hydrodynamic understanding of physical force from fluid mechanics to phenomenology and metaphysics. Physical force underwrites Hopkins' central poetic term instress.

Pertaining to Parmenides' *Aletheia*, in verging from phenomenology to metaphysics, Hopkins has already bridged the division between Parmenides' "Way of Truth" and his "Way of Opinion." He has acquired knowledge of ultimate Being through sense perceptions. But a good portion of his "Parmenides" notes apply to Being directly and without recourse to the senses. These passages respond to Parmenides' *Aletheia* and transpose Parmenides' Being into the Christian God. Yet just as Hopkins' hydrodynamic exposition of Parmenides' *Doxa* implies an analogy between physical force and metaphysical Being, so his exposition of Parmenides' *Aletheia* does as well. Importantly, Hopkins applies his principles of flushing and foredrawing to God himself. In so doing, in representing God in the language of physical force, Hopkins establishes a relationship between God and force that is something more than analogous. Hopkins' analogy between spiritual and physical energy will be the subject of the next chapter, but I would like to offer a few observations in closing.

Particularly, Hopkins emphasizes Parmenides' claim that Being/God "is the unextended, foredrawn." In saying that God is "foredrawn," Hopkins claims that God is not immaterial but concrete, and is not only universal but particular. As well, glossing his meaning of "unextended," Hopkins cites Parmenides' comparison of Being to a ball, bounded and finite. This may seem heretical, but Brown observes that "it is understandable, given [. . .] the centrality of the Incarnation to Hopkins' faith [. . .] that he finds Parmenides' conception of the necessarily determinate nature of transcendent Being especially engaging" (169). Brown's words recall St. Paul's paradox, that in the finite, delimited frame of Christ "dwelleth all the fulness of the Godhead bodily" (Col. 2:9). Such a paradox of infinity in finitude also appears in the Catholic doctrine of the Sacred Heart of Jesus. James Cotter explains the Sacred Heart as a "burl" or compacted center of being containing all things.

Being not only is foredrawn, but it is also flush. Comparing Being to a ball, Hopkins contrasts the outline and surface of ball-like Being to its "inner flushness" (*Oxford Essays*, 314). Infinite in finitude, Jesus, as determinate Being, is both bounded but contains all things. Bounded by a physical body, he nevertheless is the fulness of God and is the universal of all particulars. As universal, he flushes all things, and all things are concrete expressions of his Being.

Hopkins extends his hydrostatic binary of flushing/foredrawing from physical relations of force clear through the spectrum of Being and at last to the second person of the Trinity. In likening Jesus' determinate Being to a ball, foredrawn on the outside but flush on the inside, he anticipates his later analysis of the bubbles in his Lenten chocolate, which are similarly foredrawn by their outer film yet flushed by the expanding gas within. Other globes, balls, droplets, and bubbles sprinkle Hopkins' writing, with oil and blood typically providing the medium for these fluid spheres. In conjunction with flushing and foredrawing as the secondary aspects of stress, the bubble and sphere imagery that sprinkles Hopkins' poems and devotional writings links metaphysical Being to physical force.

4 METAPHOR VS. METONYMY: HOPKINS' FIGURES OF STRESS

The previous chapter applied Hopkins' theory of words to articulate stress not as a single term but as a matrix of meaning structured by several definitions. These several definitions shape the periphery of the matrix, but they contract together at the matrix's core to render a richly composite meaning. Hopkins' matrix accordingly falls into a concentric hierarchy, with the most simple and generalizable definitions at the periphery informing the more specialized definitions closer to the core. Thus, in its outermost and most broadly applicable definition, stress equates to physical force pure and simple. Yet as the various definitions of stress "contract" together within the core, they become more complex and more specific. Mapping Hopkins' matrix as a planetary system yields a number of definitional orbits: stress as force pure and simple; stress as interior force maintaining an object's shape; stress as interior force maintaining an object's material form; and finally stress as ontological force maintaining an object's very being. In this movement toward the core, stress acquires new signification all the while that it conserves the meaning of previous definitions. Thus, at the system's dense core, the ontological sense of stress merges with the material. The membrane between nature and supernature thins, and stress passes fluidly from the physical to the metaphysical. In short, the material world and the unseen world belong to a single universe, and the subtle energies of stress carry over from one realm to the other.

Given the importance of stress for Hopkins' ontology, this confluence of physics and metaphysics frequently manifests itself in his poems and prose. Hopkins routinely illustrates stress and instress metaphorically, as magnetism, electricity, or light. Yet how metaphorical are Hopkins' metaphors, particularly given the correspondence of physics and metaphysics within his semantic matrix of stress? Is Hopkins' instress an actual form of energy, or does it merely possess an analogical resemblance to the forms of energy Hopkins uses to describe it? In keeping with Hopkins' reverence for the Real Presence, and with his Scotist perception of Christ's Presence in nature, I propose that Hopkins' metaphors often function literally, and posit a real and essential connection between the two objects they compare.

In the following chapter, I will argue that instress is an actual force, a form of energy subtle and refined but nevertheless as real and as operative as the other forces in nature. In the present chapter, however, I will treat Hopkins' figurative language. Specifically, I will argue that Hopkins' metaphors are unusual in that they do not express likeness in unlikeness, but instead posit physical correspondence as indicative of a deeper ontological unity. In fine, Hopkins' metaphors are more than metaphorical, and suggest a literal or physical identification between the objects they compare. Accordingly, when Hopkins compares divine outstress or ontological instress to the various forms of energy in nature, his comparisons are not inert or merely metaphorical. Instead, his comparisons offer yet another instance of energy scaling the material to the metaphysical, and suggest that for Hopkins, all force -- ontological and physical alike -- partakes of a single origin and expresses an underlying unity.

4.1 Metaphor, Metonymy, and (Meta)physics

The following list samples a few instances of Hopkins' conflation of physical energy and metaphysical force:

1) "Thou art lightning and love…." (*Deutschland* 70)
2) "I did say yes/ O at lightning and lashed rod…." (*Deutschland* 9-10)
3) "Stroke and a stress that stars and storms deliver…." (*Deutschland* 45)
4) "The world is charged with the grandeur of God./ It will flame out, like shining from shook foil"[80] ("God's Grandeur" 1-2)
5) "As kingfishers catch fire…." ("Kingfishers" 1)
6) "Buckle! AND the fire that breaks from thee then…." ("Windhover" 10)

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[80] That Hopkins intended the "shining from shook foil" to recall lighting appears in a January 4, 1883 letter to Bridges: "Shaken goldfoil gives off broad glares like sheet lighting and also, and this is true of nothing else, owing to its zigzag dints and creasing and network of small many cornered facets, a sort of fork lightning too" (*Letters* 169).

7) "That Nature is a Heraclitean Fire…." (title)

8) "This … matchwood … is immortal diamond." ("Heraclitean Fire" 23-4)

9) "The Blessed Virgin compared to the Air we Breathe" (title)

10) "I say that we are wound/ With mercy round and round/ As if by air…." ("Blessed Virgin" 34-6)

11) "This is mechanical reflection and is the same as optical. All nature is mechanical, but then it is not seen that mechanics contain that which is beyond mechanics." (*Journals* 252)

12) "The energy or instress with which the soul animates and otherwise acts in the body…." (*Sermons* 137)

While this list is by no means exhaustive, it provides a brief sampling of a recurrent connection in Hopkins' writings between spiritual force and physical energy. As recent scholarship attests, Hopkins frequently expresses God's grandeur in terms of energetic systems, or through singularly spectacular displays of natural energy (lightning particularly, but also the aurora borealis, storm fronts and thunderheads, etc.). James Cotter was perhaps the first to identify Christ with the energetic wave of water in *The Wreck of the Deutschland,* and Tom Zaniello, David Levy, Norman MacKenzie, Marie Banfield, Jude Nixon, and Sarah Winters have traced Hopkins' incorporation of energetic systems -- atmospheric, meteorological, and celestial -- within his poems.[81] Likewise, John Gordon "explore[s] the implications of [. . .] electrical

[81] See Cotter's *Inscape: The Christology and Poetry of Gerard Manley Hopkins*. MacKenzie's entry in his *Readers' Guide* similarly discusses "God's Grandeur" in terms of the lightning that flames out from the charged world. For readings of the atmospheric phenomena in *The Wreck of the Deutschland,* see Banfield's "Darwinism, Doxology, and Energy Physics: The New Sciences, the Poetry and the Poetics of Gerard Manley Hopkins" (185-8), and Nixon's "'Read the Unshapeable Shock Night': Information Theory, Chaos Systems, and the Welsh Landscape of Hopkins's *The Wreck of the Deutschland.*" Likewise, Winters describes the "Heavenly Bodies in

inspiration" in *The Wreck of the Deutschland* and "The Windhover," associating the figure of lightning with "inspiration and salvation alike" in that it "enacts an arc of contact [. . .] between sky and ground," or between God and his creatures (506, 507). Gillian Beer discovers the origin of Hopkins' atmospheric conceit, "The Virgin Mary Compared to the Air we Breathe," in the experimental science of John Tyndall. As Beer relates, Hopkins' comparison of Mary and the "world-mothering air" hinges on Tyndall's discovery that suspended particles in the air reflect specific wavelengths of light energy (blue), but do not "taint" or color the light itself. Finally, James Leggio, Jude Nixon, Marie Banfield, Hazel Hutchison, and others have pointed out the overlap between Hopkins' apocalyptic imagery and the thermodynamic laws of energy.

Each of the authors mentioned above observes either a form of energy in nature (light, heat, electricity, chemical bonds, etc.) or an energetic system within nature (the atmosphere, a storm, gravitation) that functions in Hopkins' poetry to express a metaphysical truth about God, God's relationship to creation, or a person's experience of God. Hopkins is certainly not the first poet to ascribe the energies of nature to God, or to liken God's power to natural forces. But he is unusual in that he perceives nature's energies as continuous with God's power, as descendants of God's original "outstress" at the creation of the world.

Critics commonly observe the overlap in Hopkins' poems between natural energy and spiritual force, particularly God's creative power. Virginia Ridley Ellis, for example, writes that

> The power of any created thing to give off instress and to instress derives specifically and absolutely from an original and divine source, God's stress of

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the Windhover," while Tom Zaniello, in his "The Scientific Background of Hopkins' 'Loss of the Eurydice': Two Documents," describes how Hopkins' second shipwreck ode incorporates meteorological data gathered about the storm that capsized the H.M.S. *Eurydice*. Finally, David Levy's "Poet and Observer: Gerard Manley Hopkins and Some Mid-nineteenth Century Comets" traces the import of celestial phenomena in Hopkins' poems.

> energy, which charges the world with life, sustains it, keeps inscapes taughtly at tension, prevents disintegration of being. Instress is thus both the life-giving energy in any object, derived from God, and the energy given off by that object, news of its selfhood and of its maker, when it is perfectly fulfilling its God-given function. (33)

In so defining instress, Ellis positions Godly power and natural energy in a relationship of lineal descent. God's originary act of creation marks the beginning of nature, and nature's energies – or "the energy[ies] given off by [. . .] objects" -- persist as permutations of the power God exerted to bring matter into being.[82] Yet Ellis carefully qualifies her definition to preclude a direct equivalence between God's power and natural energy. In Ellis' definition, the energy given off by an object is instress only when the object "is perfectly fulfilling its God-given function." Natural energy itself is not instress, then. Instress as Ellis describes it may require natural energy, or in some way be analogous to natural energy, but the essence of instress, for Ellis, is obedience to God's will. Presumably, instress is analogous to natural energy in that, in conformity to God's will, it is active and forceful. But by Ellis' definition instress is not natural energy per se.

With due respect to Ellis, her book *Gerard Manley Hopkins and the Language of Mystery* was published in 1991, before Brown, Zaniello, and Nixon published their germinal works on Hopkins and science. Nor would Ellis have had access to Beer's seminal article, "Tyndall, Helmholtz, and Gerard Manley Hopkins: Leaps of the Prepared Imagination," also published in 1991. If anything, even though Ellis ultimately pulls back from a direct association between energy and instress, she deserves credit for positing the relation, however briefly, in the first

[82] By "natural energy" or "nature's energies" I mean the forms of energy in nature: magnetism, electricity, heat, light, mechanical force, etc.

place. My point here is not to criticize her work, but to show how scholars have traditionally placed instress and the natural forms of energy in an analogical or metaphorical relationship.

Speaking in 2006, Glenn Hughes seconds Ellis' definition of instress. For Hughes, the energy of instress takes two forms. His first form of instress, closely modelled on Ellis' description of the term, likewise depicts energy emanating from God to create and subsequently to uphold all things. As Hughes explains, instress is "the force, the tensional dynamism, or 'stress,' that holds together a thing's form. Ultimately [. . .] instress is the active presence of God's will sustaining a thing in its being or essence" (118). Hughes' second form of instress designates "the subject's empathic perception of [another] thing's instress, the felt apprehension of [. . .] its stress or energy of being" (119). Thus, instress in this guise is a two-part operation, and depends on a union of object and subject. Perceived objects exert their stress outwardly, and perceiving subjects extend themselves to take in the external stress of an object. In this way, instress is "a kind of bond, or better yet an identity that can emerge between a perceiving subject and a perceived object" (119). Hughes quotes Hans Urs von Balthasar approvingly in that the subject's instress is 'an answering stress, so that the [subject] can hold communion with the stress of things and experience them within. . . . The objective stress is taken up by the subject that is open to it' (quoted 119).

Yet while Hughes consistently employs the vocabulary of stress and energy, the relationship he describes between instress and the energies of nature is likewise analogical or metaphorical. At one point, Hughes writes that "for Hopkins, everything in nature *is* the very energy, the incarnated stress, of God's immutable beauty" (120, Hughes' emphasis). While this claim unites nature with God, the "energy" in this passage is of a metaphysical kind – it is the energy of "God's [. . .] beauty," not of electricity, heat, magnetism, chemistry, and mechanical work. Hughes' subsequent analysis of psychological energy reinforces the analogical nature of instress. Hughes surveys Hopkins' discussion of two forms of intellectual energy – 'a transitional kind, when one thought or sensation follows another' and 'an abiding kind [. . .] in which the mind is absorbed [by] a single thought' (Hopkins, *Oxford Essays* 307, quoted in Hughes 120). Although Hughes follows Hopkins in referring to mental instress as "energy," he does not associate this psychological or neurological energy with the energy exerted by things in nature.[83] Once more for Hughes, the various divine, natural, and psychological forms of energy are merely analogous, and no underlying identity reconciles their inherent distinctions.

If Ellis' book (1991) and Hughes' lecture (2006) articulate the majority position within Hopkins scholarship, then Hopkins' terms stress and instress fracture and break apart in their three-fold application to God's work, the natural energies of creation, and the personal and psychological energies of human beings. Such treatment of instress implies that while the natural energies of the world may be likened to God's creative power or to the mental energy of the mind, the material, the mental, and the metaphysical are ultimately irreducible and constitute three distinct and impermeable spheres. Contrarily, building upon previous chapters' discussions of stress, I argue that instress is synonymous with energy in its real or literal sense, and that the various forms of natural, psychological, and spiritual instresses are ultimately reducible, much as magnetism, heat, light, sound, electricity, and work are ultimately reducible as various expressions of energy. In coining his term instress, then, and in extending its application to metaphysics, psychology, and physics, Hopkins does for his poetry what the first law of

[83] Neurology is a surprisingly old term. According to the *OED*, the noun form dates to the latter 1600s, while the adjective form dates to the 1830s (*"Neurology," "Neurological"*).

thermodynamics did for science, showing the fundamental identity of various forms of energy by subsuming them under a single term.[84]

If spiritual, psychological, and natural energies are consanguineous, or are parts of a larger whole, then Hopkins' metaphors of energy function more like metonymy than like true metaphor. Metaphor posits a semantic association between physically incongruous objects. Indeed, if the objects are not physically incongruous, then the metaphor breaks down and fails to work.[85] Metonymy, contrarily, posits a physical kinship between the objects associated. In its most extreme forms (Fontanier's "relations of connection"), metonymy posits an ontological identity that subsumes the objects compared. However, less rigorous forms (Fontanier's "relations of correlation") link objects more tenuously, and posit relations of sequence, as in cause-and-effect metonymy, or of proximity, as in spatial metonymy, instead of ontology. Nevertheless, at a minimum, all metonymy require physical correspondence of some sort, whether sequential, proximal, or ontological. Thus the relation of metonymy is real and objective while that of metaphor is semantic or subjective.

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[84] Please see my discussion of thermodynamics' first law in Chapter One. It is important to note that the laws of thermodynamics were a distinctly high Victorian contribution to science. The experiments that prompted the laws had their roots in the 18th and early nineteenth centuries, and included sources as diverse as Rumford's account of frictional heat (1798), Sadie Carnot's description of heat flow in a steam engine (1824), Mayer's accounts of chemically and mechanically generated heat (1840-5), Faraday's experiments with chemistry, electricity, magnetism, and light (1820s-1845), and Joule's experimental determination of the mechanical equivalent of heat (1845). Nevertheless, it was not until the 1850s that Thomson, Clausius, and Rankine would develop the theory and laws of thermodynamics to account for the previous decades' experimental results. Accordingly, the laws that articulated the unity of nature's energy in all of its forms were a Victorian contribution. Much the same, Hopkins' theory of instress, or his articulation of the unity of natural, neurological, and spiritual energy, is a fittingly Victorian contribution.

[85] See my discussion of Richard's and Ricoeur's theory of metaphor, below. The necessary tension of metaphor stems from the physical incongruity (the "absurdity," in Ricoeur's words) of the objects compared.

If Hopkins intends to posit a real or actual connection between metaphysical, mental, and physical energies, then his metaphors of energy function metonymically. Two difficulties complicate such a claim, however. First, in saying that Hopkins' metaphors function metonymically, I set form and function at odds with each other, and claim that Hopkins' comparisons, though ostensibly metaphorical in grammatical structure, act like metonymy. I will attempt to address this difficulty later in this chapter by invoking Hopkins' ontology, specifically his perception of the formal correspondence of all created things in Christ.

Second, my characterization of Hopkins' analogy as "metonymic" is fraught with the notable difficulty that no other form of metonymy sets forth the relation that I claim Hopkins' metonymy does. If I am correct that Hopkins relates the energies of spirit, mind, and matter as alternate expressions of a single universal "outstress," then the relationship that obtains among these energies is that of part to part within a whole. However, no other class of metonymy takes this form. Most kinds of metonymy (Fontanier's "relations of correlation" -- spatial, cause-for-effect, instrument-for-action, etc.) posit spatial or sequential correspondence. Only synecdoche (Fontanier's "relations of connection") posits an ontological connection between the two objects. But synecdoche compares part to whole, not part to part within a whole as I describe of Hopkins' figures. Implicitly, my argument involves a claim that Hopkins practiced an unusual form of comparison in creating his unique metonymical analogies of energy.[86]

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[86] Again, in positing an ontological connection as opposed to a sequential or spatial correspondence, Hopkins' metonymy is unusually strict, and belongs with synecdoche in Fontanier's "relation of connection" instead of his "relation of correlation." To quote Ricoeur's explanation, Fontanier's correlation "brings together two objects, each of which constitutes an absolutely separate whole'" (*The Rule* 56). Contrarily, "in the relationship of connection, two objects 'form an ensemble, a physical or metaphysical whole, the existence or idea of one being included in the existence or idea of the other'" (*The Rule* 56). If Hopkins posits metaphysical, psychological, and physical forces as alternate expressions of a unitary source of stress, then the relationship that obtains is not between 'absolutely separate whole[s]' but between parts that

But while Hopkins' figures are unusual, and do not fit well with the customary forms of metonymy, they still resemble metonymy functionally in that, in contrast to metaphor, they posit an actual and physical correlation between the objects compared. As may be said of his poetry generally, Hopkins' rhetorical figures are formally adventurous. Nevertheless, in maintaining the concrete or physical correspondence of objects, Hopkins' figures partake of the essential activity of metonymy.[87] Accordingly, I characterize Hopkins' figures as metonymic in this qualified sense.

While a complete treatment of Hopkins' analogy lies outside the scope of this chapter, I will assess one of Hopkins' most recurrent comparisons, that between God's "outstress" within nature and the various energies of nature. To examine Hopkins' figure, I will employ Paul Ricoeur's and Raymond Wilson's structuralist analyses of metaphor and metonymy. First, however, I will define metonymy and metaphor as these tropes have traditionally been regarded, and discuss their salient forms.

4.2 Structure of Metonymy: Form and Function

Classical rhetoricians viewed metaphor as a matter of naming or denomination, or of replacing one word with another. Aristotle famously defined metaphor as "the application of an

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'form an ensemble, a physical or metaphysical whole.' Accordingly, as I will discuss in more detail in the following chapter, Hopkins' metonymy of stress resembles Fontanier's relation of connection, and 'the existence or idea of one [form of energy is] included in the existence or idea of the other.'

For Fontanier, the difference between "correlation" and "connection" was large enough for him to separate the two classes entirely. Most modern theorists do not follow Fontanier's taxonomy, however, and group synecdoche as a form of metonymy. Despite this, Fontanier's categories of correspondence and connection provide an excellent description of the types of relationships possible within the genus of metonymy. Hopkins' relationship between physical, psychological, and metaphysical stresses is like synecdoche in that it posits connection instead of correspondence. Accordingly, I refer to Hopkins' metonymy as a "rigorous" or "strict" form of metonymy.

[87] For a fuller explanation of this sentence, please see the following section, "Structure of Metonymy: Form and Function."

alien name by transference either from genus to species, or from species to genus, or from species to species, or by analogy, that is, proportion" (*Poetics* 77-9). Significantly, Aristotle defined metaphor while articulating the various properties of words, asserting that "every word is either current, or strange, or metaphorical, or ornamental, or newly-coined, or lengthened, or contracted, or altered" (77).[88] From Aristotle's treatment of metaphoricity as a property of a word, it appears that classical grammarians and rhetoricians regarded metaphor as consisting of a single word, an "alien" or unexpected word that replaces the conventional term.

Instead of defining metaphor as a species of trope, Aristotle defines it as a genus comprising several species, including synecdoche and metonymy. In the definition of metaphor cited above, the first class that Aristotle describes, "genus to species," is the inverse of synecdoche and expresses the transference of a property from whole to part. The second class, "species to genus," is synecdoche, more commonly defined as "part to whole." The third class, "species to species," potentially encompasses a number of specific tropes, including metonymy, simile, and the modern sense of metaphor proper.[89] The fourth class, "analogy" or "proportion," identifies yet another species within the metaphorical genus (see below).

Twentieth and twenty-first century readers typically regard metaphor as a clash – or, as I.A. Richards might say, a "tension" -- between two terms. Accordingly, modern readers think of

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[88] Ricoeur argues that "word" is better translated as "noun" (*The Rule* 16). As Ricoeur argues, "the noun is the pivot" upon which Aristotelean metaphor turns (16). Ricoeur does make some allowance for metaphor to signify other parts of speech, but he stresses nouns as the primary parts of speech that Aristotle intends.

[89] Aristotle does not mention simile in his *Poetics*. However, he does relate metaphor and simile in his *Rhetoric*. Simile, then, is a "developed" or "explicit" metaphor (Ricoeur 24-25). As well, in including the "modern sense of metaphor proper" within Aristotle's metaphorical genus, I follow D.W. Lucas' comment that "[Aristotle's] word [*metaphora*] is used in a wider sense than English "metaphor," which is mainly confined to the third and fourth of Aristotle's [metaphorical] types" (204).

a metaphor as a sentence like "all the world's a stage."[90] Even when the metaphor itself does not take the form of a sentence (for instance, consider the phrase "the sleep of death"), modern readers take it to imply a sentence ("Death is sleep"). Aristotle, however, understood metaphor to work not by a clash between two words in a sentence, but by substitution or replacement of one word for another. For Aristotle, this substitution is total: not only does the second term (the vehicle) take the place of the first, but the first term (the tenor) goes entirely unmentioned in the speech or on the page, and must be inferred by listeners or readers. As Robert Fogelin observes,

> It is important to recognize the type of construction that Aristotle takes as paradigmatic of metaphors. In the example he presents, Achilles is *referred* to as a lion rather than *called* a lion. That is, the construction looks like this:
>
> (1) The lion [i.e., Achilles] leapt
>
> rather than this:
>
> (2) Achilles is a lion. (28)

This substitutionary nature of metaphor as a genus appears particularly clearly in Aristotle's closely circumscribed fourth species of metaphor. This species of metaphor functions by comparing the second terms of two ratios in a proportion. To sample Aristotle's explanation, take the proportion "Bacchus is to cup as Mars is to shield." In Aristotle's example, the second term (cup) of the first ratio (Bacchus is to cup) crosses over and replaces the second term (shield) of the second ratio (Mars is to shield). Alternately, the second term of the second ratio may cross over and replace the second term of the first ratio. Thus, a "shield" can be called the "cup of Mars," or a "cup" can be called the "shield of Bacchus." Importantly, however, when this class of metaphor appears in speech, listeners must infer that the "cup of Mars" is a shield. The

[90] I should note that my example from Shakespeare precedes the modern "tension" theory of metaphor developed by twentieth century structuralist critics like Richards and Ricoeur.

connection occurs implicitly instead of explicitly, and the word “shield” goes entirely unmentioned in the utterance that listeners hear. Similarly, hearers or readers of the metaphor “the shield of Dionysus” understand that the “shield” is a cup, but the word “cup” is omitted. In this way, metaphor as Aristotle conceived the trope involves complete substitution, so complete as to expunge the tenor from the very page or speech.[91] Thus, the modern formula for metaphor, “X is Y,” may describe the semantic function of Aristotelean metaphor, but not its form as it appears on the page or as it is heard in speech.

While Aristotle is unusual among classical authorities in treating metaphor as a genus instead of a species, he is entirely conventional in identifying the essential function of metaphor as “transference” or substitution (*Poetics,* 77).[92] If substitution identifies the essential function of metaphor, then Aristotle’s purpose in defining metaphor as a genus instead of a species becomes clear. Since, by Aristotle’s definition, synecdoche and metonymy also function by substituting one word for another,[93] they may be subordinated to metaphor as particular instances of it.[94]

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[91] Modern theorists such as Wilson and Lodge still consider metaphor to function by substitution or replacement. Instead of a formal replacement, however, where the vehicle banishes the tenor from the very page, Wilson means a functional or semantic replacement, where the vehicle poses an absurd contradiction of the tenor that must be figuratively resolved.

[92] Ricoeur argues that Aristotle “was confused” in considering transference to necessitate substitution. Ricoeur points out that the terms are not synonyms, and the one does not require the other (*The Rule* 19). By “transference,” Aristotle means that the figurative name for the object is borrowed or transferred from an “alien” domain (*Poetics* 77). Substitution, as I explain above, means that the figurative or transferred name cancels or replaces the conventional name, or that the vehicle banishes the tenor from the actual page. Taking the modern form of metaphor as an example, “X is Y,” Ricoeur argues that transference does not necessitate substitution, or striking the tenor from the text. As is customary in modern metaphor, the conventional and the alien terms may both appear on the page in explicit comparison.

[93] Twentieth century structuralists distinguish metonymy and metaphor in that “both metaphor and metonymy *appear* to operate through replacement; however, the *true* replacement in metaphor contains the element of difference while metonymy’s *apparent* replacement does not” (Wilson 296). Note however, that the modern sense of substitution or replacement differs from the classical sense. The classical sense involves formal or grammatical replacement, while the modern sense involves functional or psychological replacement. See footnote 12, above. As well,

Quintilian, however, classifies metaphor, synecdoche, and metonymy independently of one another as separate tropes. While in so doing, Quintilian departs from Aristotle's taxonomy of metaphor as simultaneously a genus and a species, Quintilian follows his predecessor in his insistence that metaphor operates by formal substitution (or by "banishing" the tenor from the page). This appears in Quintilian's claim that "On the whole, metaphor is a short comparison; differing in this respect, that, in the one, an object is compared with the thing we wish to illustrate; in the other, the object is put instead of the thing itself" (126). If the vehicle (or "object") "is put instead" of the tenor (or "thing"), then the tenor is implicit, or is absent from the stated comparison in the speech or on the page.

Pertaining to metonymy, Quintilian's *Institutes* is particularly helpful because it specifies the various forms that metonymy typically assumes. Quintilian defines metonymy as the "substitution of one word for another," and identifies a number of subclasses (II.129).[95] Quintilian illustrates the first subclass, in which the inventor stands in for the invention, through poetic references to the Greco-Roman deities. Thus, classical poetry often speaks of Neptune in place of the sea (Neptune created or "invented" the sea), or Ceres instead of grain (grain is

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please see my discussion later in this chapter of metaphorical difference and metonymical correspondence.

[94] At this point, readers may wonder why, if metaphor as a genus functions through substitution, Aristotle in other writings (his *Rhetoric*) classifies simile as a type of metaphor. After all, a simile names its tenor and vehicle explicitly, and the vehicle of a simile does not replace the tenor in a formal sense or banish it from the page. This challenge must be admitted. All the same, a simile is a type of metaphor in that it makes explicit what a metaphor keeps implicit. Ricoeur remarks on the ways Aristotle's taxonomy of metaphor deconstructs or "jumbl[es] classification" (*The Rule* 21). Perhaps, in violating the substitutional logic of Aristotle's metaphoric taxonomy, simile contributes to this jumbling effect.

[95] Aristotle, had he lived long enough to read Quintilian's *Institutes*, might object that Quintilian's definition of metonymy fails to identify any distinction between metonymy and metaphor. If metaphor puts "the thing" for "the object" as Quintilian claims it does, then it also "substitutes one word for another." As such, Quintilian's definition of metonymy recapitulates his description of metaphor.

Ceres' invention). Quintilian continues to list a number of other metonymical relations: container for content (drinking a "cup" instead of the liquid in the cup); possessor for possession (reading "Virgil" instead of Virgil's poetry); cause for effect (speaking of "rash anger" instead of a "rash deed" caused by anger); and plural for singular (a person's "looks" instead of his "look"). Other common kinds of metonymy not mentioned by Quintilian include instrument for action ("knifing" someone instead of "stabbing" him) and location for thing/person (the "Stagirite" for Aristotle). Quintilian treats synecdoche (part-to-whole) as a separate trope.

If Aristotle and Quintilian represent, in a general sense, the various classical understandings of metaphor and metonymy, then Roman Jakobson, I.A. Richards, and Paul Ricoeur may be taken to represent modern conceptions of these rhetorical figures, conceptions particularly influential in twentieth century structuralism. Roman Jakobson redefined metaphor and metonymy as fundamental principles of language instead of discrete figures of speech. In his *Fundamentals of Language*, Jakobson repeatedly refers to language as a code that speakers manipulate to create meaning. While speakers have a measure of freedom in selecting and combining their words, the structures within the linguistic code limit speakers' choice, and speakers enjoy only those freedoms the code allows. For example, when speakers select a word, they must choose one word from a pool of related words. The linguistic code determines the pool; speakers draw from the pool. Similarly, in combining words to create phrases and sentences, speakers have a measure of freedom, but they must abide by grammatical and idiomatic conventions set by the linguistic code.

Accordingly, Jakobson identifies two partial freedoms essential to language: selection and combination. In a general (and admittedly imprecise) sense, combination roughly equates to style while selection roughly equates to content. More precisely, selection describes a speaker's choice of elements from the linguistic code. To make this choice, the speaker surveys a network of synonyms, images, objects, and other "entities conjoined in the code" (61). Connections between things (words as well as images and objects) stem not from the individual speaker then, but from the code itself, and speakers sample or replicate these connections in creating an utterance. Selection therefore entails a choice among a limited number of possibilities. Importantly, since connections between things exist within the code and not necessarily within the utterance or even the speakers' mind, the possibilities not selected remain possible. At a later point in the utterance, these heretofore unchosen possibilities may be chosen to replace former selections. In Jakobson's words, "a selection between alternatives implies the possibility of substituting one for the other [. . . .] Actually, selection and substitution are two faces of the same operation" (60).

The principle of selection finds its epitome in the figure of metaphor. In devising a metaphor, the speaker surveys the network of connections between objects furnished by the various codes (linguistic, certainly, but apparently social as well) s/he has experienced. The speaker replaces one object with an associated object, and the resulting metaphor recapitulates the structure of the socio-linguistic code from which it stems. In two ways, then, metaphor epitomizes the principle of selection that is active in any utterance, poetic or pedestrian. First, metaphor involves a choice among alternatives furnished by the linguistic code. And second, metaphor illustrates the suppressed salience of "entities conjoined in the code but not [yet conjoined] in a given [utterance]" (61).

Combination opposes selection as the other freedom available to speakers in forming an utterance. If selection entails choosing among the alternatives furnished by a code, combination consists in arranging these elements in a comprehensible fashion. In sum, combination describes a speaker's effort to match words together and to build words into phrases and larger units of meaning. As does selection, combination depends upon the structures of the linguistic code.

Beyond grammar and idioms, however, combination also applies to what Jakobson dubs "contiguity" or "contexture," or the proximal grouping of associated objects and images within an utterance. This contiguity of objects in an utterance recapitulates associations between objects in the linguistic code. Ultimately, Jakobson aims not merely to account for the structure of a specific utterance but to analyze the structure of the linguistic code as expressed through utterances. In examining contexture and contiguity, then, Jakobson is as interested in the contiguity of objects in the socio-linguistic code as he is in the contiguity of objects in a specific instance of speech or writing.

Jakobson's discussion accordingly turns to the contexture of objects in the code of people's lived experience.[96] Particularly, in his examination of similarity disorder, Jakobson observes that while aphasic speakers may not be able to provide the conventional noun to name an object, they can name it according to the context within which they have experienced it.[97] Thus, one man that Jakobson recalls could not name a knife a "knife," but he could identify it as a "pencil sharpener," an "apple-parer," a "bread-knife," or a "knife-and-fork." Even though the man could supply several contextual descriptions that contained the term "knife," the man was unable to name the knife simply as "knife" (65). In effect, the man named the knife not through

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[96] If I interpret Jakobson correctly, his implicit claim is that the linguistic code encapsulates collective experience, and a particular individual's application of the linguistic code follows individual experience. Language and socialized experience are intrinsically linked.

[97] Jakobson's interest in aphasia becomes clear in his claim that aphasic speakers regress through the same stages through which infants progress. In studying aphasic speakers, Jakobson hopes to learn about language acquisition, albeit in reverse. Jakobson finds that there are two kinds of aphasic speakers – those who suffer from an inability to select words, and those who suffer from an inability to combine them meaningfully. He adduces the two-fold nature of aphasia to support his binary model of language as consisting of the two principles of selection and combination.

selection of the appropriate word, but through combination with other words. Similar to a blind man with an extraordinary sense of hearing, the man compensated for his inability to exercise the first principle of language, selection, with his extraordinary ability to exercise the second, combination.

As the aphasic man's speech implies, the combination principle finds its epitome in metonymy. In replacing one term with a conventionally associated term, metonymies show the hidden contiguities between terms within the socio-linguistic code. Given that metaphor and metonymy represent the two essential principles of language, selection and combination, then all language-making can be considered a joint exercise of the metaphorical and metonymical modes of speech. By Jakobson's theory, metaphor and metonymy in their extended sense are not merely tropes or figures of speech, but rather are modes of language-making that subsume all tropes and all language production.

A particular strength of Jakobson's system is that it expands the domain of metaphor and metonymy in treating them as qualities or principles instead of grammatical tropes. Jakobson's qualitative treatment of metonymy and metaphor allows him to theorize about language production and linguistic debility. A similar qualitative treatment has allowed subsequent critics, namely David Lodge and Raymond Wilson, to classify various rhetorical tropes (symbols, particularly) as either "metaphorical" or "metonymic." In effect, Jakobson's theories freed the terms metaphor and metonymy to be applied to literary patterns and structures of imagery that are not expressly metaphors or metonyms. In classical grammar, metaphor requires renaming, or substituting an "alien" noun in place of the conventional word for an object. Critics following Jakobson's theories, however, argue that symbolic imagery can be referred to as "metaphorical" even if it does not expressly rename the original object.

A weakness of Jakobson's system, however, is that it empties function of form. If the term metaphor applies to a category of language, then what should the conventional grammatical form of metaphor be called? What should the conventional form of metonymy be called? In short, if grammatical form is passed over, then what distinguishes the formal trope of metaphor from other tropes (particularly symbols) that function similarly by selection and substitution? Much the same difficulty persists for metonymy – if metonymy is a category, then what distinguishes the traditional trope of metonymy from other tropes that are similarly metonymical?

This challenge has been taken up by later theorists, particularly David Lodge and Raymond J. Wilson. Wilson finds symbols to partake of both metonymy and metaphor, and accordingly sets forth a four-fold taxonomy of metaphorical figure, metaphorical symbol, metonymical figure, and metonymical symbol. As this taxonomy suggests, a symbol may be either metaphorical or metonymical. Wilson discriminates metaphorical and metonymical figures from metaphorical and metonymical symbols in that symbols work by contextual implication, and require an inference from the reader, while the traditional figures do not. By Wilson's system, the metaphorical figure (a traditional metaphor) explicitly compares tenor to vehicle in the form of a grammatical sentence. A metaphorical symbol, on the other hand, operates by suggestion and implication, and does not explicitly link tenor to vehicle. Readers must infer this linkage from contextual cues within the text. Wilson also distinguishes between the metonymical figure and the metonymical symbol in a similar fashion, again distinguishing the two according to the necessity of inference. The metonymical figure relies on convention (Jakobson might say the "linguistic code") to associate related terms, and consequently does not require an inference to be understood. Since sailors by convention are referred to as "hands," the expression "all hands on deck" does not require the reader to infer the connection between "hands" and "sailors." On the other hand, if an author were to use less conventional terms (Wilson suggests referring to ships as "nails" instead of the conventional metonym "sails"), he would then need to provide systematic contextual clues to enable readers to make the association (298). Such systematic implication would require the reader to make an inference and would consequently result in symbolism.

In contrast to Jakobson's functional analysis of metaphor and metonymy as modes of language creation, I.A. Richards and Paul Ricoeur consider metaphor formally, as a grammatical phenomenon. By Richards' and Ricoeur's account, metaphor is a syntactic effect that arises from the tension between the subject and the predicate of a sentence. Opposing Aristotle and Quintilian, who considered metaphor to be a simple matter of replacing a conventional term with an alien word, Ricoeur writes that metaphor is an effect of "impertinent predication." Ricoeur intends his term "predication" grammatically, and means that a metaphor consists of a sentence, not a single word, and involves an absurd or shocking disruption between subject and predicate.[98] While a literal statement matches the subject with an expected or "pertinent" predicate, a metaphor shocks readers or listeners by linking the subject with a predicate that, from a literal perspective, is absurd. Ricoeur follows I.A. Richards in stressing that metaphor functions not just by replacing an expected predicate noun with an unexpected one, but through the tension generated by the total sentence, or by the disjunction between the subject of the sentence and its "impertinent" predicate. In Ricoeur's words, a metaphor occurs when a speaker

[98] Granted, not all metaphors appear as sentences. Many metaphors appear as words or phrases instead of clauses. Thus, the expressions "mantle of sorrow" and "evening of life" are metaphors, even though they are not sentences. However, even if a metaphor appears as a single word or phrase, it implies a clause in which a subject noun compares to a predicate noun. Thus, the metaphor "mantle of sorrow" implies the clause "sorrow is a mantle," and the metaphor "evening of life" implies the clause "life is a day" or "old age is evening."

sets "two terms [. . .] in tension. And only the ensemble constitutes the metaphor. So we should not really speak of the metaphorical use of a word, but rather of the metaphorical utterance" (*Interpretation Theory* 50).

As Ricoeur elaborates, "metaphor is the result of the tension between two terms in a metaphorical utterance" (*Interpretation Theory*, 50). Ricoeur presently emends this statement, however, observing that "what we have just called the tension in a metaphorical utterance is not really something that occurs between two terms in the utterance, but rather between two opposed interpretations of the utterance" (50). Ricoeur explains that a metaphor poses an interpretive crux, forcing listeners either to construe the sentence literally or to impose a figurative "twist" upon the literal words (50). The metaphor functions by virtue of the tension between its literal claim and listeners' figurative conciliation of the literal claim. Effectively, the metaphorical utterance poses a literally "absurd" claim which listeners must reconcile with their understanding of the world. In order to effect this reconciliation, the listener allegorizes the literal claim, or transmutes its literal import to a figurative meaning. Thus,

> the strategy of discourse by means of which the metaphoric utterance obtains its result is absurdity. This absurdity is only revealed through the attempt to interpret the utterance literally. [. . .] The metaphorical interpretation presupposes a literal interpretation which self-destructs in a significant contradiction. It is this process of self-destruction or transformation which imposes a sort of twist on the words, an extension of meaning thanks to which we can make sense where a literal interpretation would be nonsensical. Hence a metaphor appears as a kind of riposte to a certain inconsistency in the metaphorical utterance literally interpreted. (*Interpretation Theory,* 50)

Critically, however, the literal meaning of the metaphorical sentence does not evaporate in the transaction. Ricoeur stresses that “it is the conflict between [the literal and the figurative] interpretations that sustains the metaphor” (*Interpretation Theory*, 50). Similarly, Ricoeur claims that “the metaphorical interpretation presupposes a literal interpretation” (50). The “extension” that Ricoeur speaks of from the literal to the figurative is not a one-time event then, nor is it a one-way transaction. Instead, the tension of a “living” metaphor implies a continuing dialectic between literal and figurative interpretation. This dialectic movement between the literal and the figurative creates the metaphor’s essential tension and preserves its life. Contrasting live and dead metaphors, Ricoeur writes that “live metaphors are metaphors of invention within which the response to the discordance in the sentence is a new extension of meaning” (52). As soon as listeners cease to sense the cognitive discordance of the literal words, they also cease to make “new extension of meaning,” and the metaphor’s life expires with its tension. At this point, the now-dead metaphor “really no longer [is a metaphor] properly speaking” and “becomes part of our lexicon” (52).[99] Contrarily, a living metaphor that retains its sense of literal absurdity likewise retains its tension and life. Ricoeur remarks upon the “infinite” reciprocation between literal absurdity and figurative conciliation, stating that “tension metaphors are not translatable

[99] Ricoeur’s discussion of living and dead metaphors recalls George Orwell’s comments about “dying metaphors” in his essay “Politics and the English Language.” According to Orwell, “a newly invented metaphor assists thought by evoking a visual image, while on the other hand a metaphor which is technically ‘dead’ (e.g. *iron resolution*) has in effect reverted to being an ordinary word and can generally be used without loss of vividness” (255). Both Orwell and Ricoeur see a living metaphor as one that stirs readers to consider the concrete imagery of the comparison. For Orwell, the reader’s ability to see the concrete objects makes an impression that clarifies thought. For Ricoeur, the reader’s ability to “see” the absurdly incompatible images generates the necessary tension to prompt a figurative reinterpretation of the metaphorical utterance. A dead metaphor, on the other hand, does not induce readers to consider the tenor or vehicle as concrete objects. As Orwell and Ricoeur both argue, dead metaphors do not actually function as images. When hearing the phrase “iron resolution,” for example, few listeners actually picture a piece of iron. Instead, most listeners treat the two-word phrase as a single word with simple denotative meaning instead of figurative meaning.

because they create their meaning. This is not to say that they cannot be paraphrased, just that such a paraphrase is infinite and incapable of exhausting the innovative meaning" (52). A tension metaphor has "infinite" meaning because the dialectic between its literal and figurative senses continues without cessation. As long as the literal claim of the metaphor continues to generate a sensation of absurdity, listeners will continue to generate new figurative meanings.[100]

Raymond J. Wilson, in developing his fourfold taxonomy of metaphorical figure, metaphorical symbol, metonymical figure, and metonymical symbol, addresses Ricoeur's theory as well as Jakobson's. Pertinent to my purposes in this chapter, Wilson adapts Ricoeur's explanation of tension to express the critical difference between metaphor and metonymy. According to Wilson, what distinguishes metaphor from metonymy is that the hearer of a metaphor "discards" the vehicle while the hearer of metonymy "retains" it. Distinguishing between metaphorical and metonymical symbols, Wilson writes that "the reader's mind retains the vehicle" of a metonymy (299). Contrarily, at an earlier point in the article, Wilson writes that "the reader's mind must discard the [. . .] vehicle" of a metaphor (297).

In describing the metaphorical vehicle as being "discarded," Wilson offers a psychologically causative explanation of the process by which, according to Ricoeur, the listener moves from a literal interpretation of the metaphorical sentence to a figurative understanding of it. By Wilson's telling, because metaphor posits a connection between two physically unlike things, listeners make figurative sense of the metaphor by stripping the vehicle of its concrete, physical meaning and reducing it to an idealized quality. As Wilson explains,

[100] Phrased as such, this aspect of Richards' and Ricoeur's criticism approaches reader response theory. It is possible to say that "the text" generates new figurative meanings instead of listeners or readers, but the fact that meaning stems from a sensation of absurdity implies that at some point a thinking human reader or listener must be involved.

> in the sentence 'The man is a rock,' we assume that the reader's mind intuitively and instantly rejects the literal reading since human beings have none of the physical hardness and inertness of rocks [. . . .] After rejecting the literal interpretation, the reader, guided by what Ricoeur calls the strategy of 'absurdity', finds an unexpected overlap of meaning, such as firmness of character and emotional stability of the man, parallel to the rock's physical firmness and stability. ("Ricoeur's 'Allegory'," 294-5).

In this example, Wilson equates Ricoeur's interpretive strategy of absurdity with emptying the vehicle of a metaphor of concrete or physical content. As Wilson reasons, the literal difficulty of reconciling a man to a rock inheres in their physical differences. The man is fleshy; the rock is hard. However, if the physical nature of either the man or the rock is transmuted to an ideal quality, the physical negation between the two objects may be superseded. In Wilson's example, listeners discard the rock as a physical object, transmuting its literal hardness to a quality of firmness or stability which may then be applied to the man. In this manner, Wilson explains Ricoeur's "self-destruction of the literal" as a discarding or emptying out of the vehicle's concrete objectivity.

Wilson's adaptation poses several apparent discrepancies that must be resolved before his system can be applied. First, Ricoeur says nothing about discarding the vehicle of a metaphor.[101] For Ricoeur, a metaphor's tension stems from the conflict between the metaphorical utterance's literal and figurative interpretations, not between the utterance's tenor and vehicle themselves. In

[101] Ricoeur does write that the "primary signification" of allegory may be "eliminated once [the allegory] has done its job" (56). But Ricoeur is speaking of allegory here, not necessarily metaphor. To be more precise, Ricoeur speaks of the "primary signification" of allegory here, not necessarily the vehicle of a metaphor. I do believe that Wilson is correct in mapping "allegory" onto metaphor and "primary signification" onto the metaphorical vehicle, but these developments must be scrutinized before they may be accepted.

Ricoeur's words, "it is a conflict between [. . .] two interpretations," the literal and the figurative, "that sustains a metaphor," not any supposed conflict between the tenor and vehicle (*Interpretation Theory* 50). Ricoeur describes the "literal interpretation" of the metaphor (an interpretation which includes vehicle as well as tenor) "self-destruct[ing]," not the vehicle itself doing so (*Interpretation Theory* 50). Thus, Wilson reads "vehicle" where Ricoeur expressly says "literal sense." Second, even if the self-destruction of the literal sense of a metaphor implies that the metaphor's vehicle must be discarded, Wilson treats discarding as a one-time occurrence while Ricoeur treats self-destruction as a dialectical moment instead of a time-bound event. Ricoeur's repeated assertions of the literal meaning's importance in generating the essential life and tension of the metaphor suggest that the self-destruction of the literal is a reversible, reciprocal, and repeatable process. Contrarily, Wilson's claim that the vehicle is "discarded" suggests a one-time transition from the literal to the figurative.

However, these apparent discrepancies resolve upon further analysis. The first resolves readily in that Ricoeur presents a process while Wilson represents the mechanism by which the process works. Simply put, Ricoeur tells what readers do (exchange a literal interpretation for a figurative one) while Wilson explains how they do it (by transmuting the physical substance of the vehicle to an idealized quality). The second discrepancy, however, poses more of a problem. Ricoeur expressly states that a metaphor's "life" stems from the persistent tension between its literal and the figurative meanings. Wilson, contrarily, makes no provision to return the metaphorical utterance to its literal meaning, or to recover the concrete substance of the vehicle upon which the metaphor's literal meaning depends. However, Wilson's readers should keep in mind that his point is not to distinguish living from dead metaphors, nor to express the dialectic tension that causes a metaphor's infinite meaning. Instead, Wilson's purpose is to distinguish metaphor from metonymy. Wilson does not entertain the fluid exchange between a metaphor's literal and figurative meanings, but rather identifies static differences between metaphor and metonymy. Accordingly, Wilson isolates one moment in the dialectic process of metaphor to distinguish metaphor from metonymy.

As a final result, Wilson's elaboration develops several aspects of Ricoeur's theory of metaphor. Primarily, metaphor juxtaposes likeness with unlikeness or "[sees] the similar in the dissimilar" (Ricoeur, *The Rule* 6). In metaphor, while a common property between two things may create resemblance, the things themselves are essentially distinct. Accordingly, Ricoeur writes that metaphor operates by "absurdity" and "semantic shock" (*Interpretation Theory* 50, "Imagination" 7). The reader observes the absurdity of a literal equation of the two compared things, and resorts to an "allegorical" reconciliation between them. Crucially, this allegorical reconciliation strips the metaphor's vehicle (usually, the second term in a traditional or grammatical metaphor) of its concrete objectivity. Instead of representing a discrete object, then, the vehicle represents a disembodied quality. Upon first encountering the Shakespearean metaphor "All the world's a stage," for example, the reader immediately realizes the absurdity of supposing the world to be a literal stage, and accordingly interprets the sentence allegorically to mean that the world is like a stage in that much as actors play many roles, people's identities change throughout life. Thus the concrete literality of the comparison's vehicle (the stage) evaporates, leaving behind an allegorical comparison of the world to a certain quality of the stage.

Wilson's elaboration also develops Ricoeur's incipient division of metaphor and metonymy. In truth, Ricoeur writes very little about metonymy, and Wilson's distinction between the two figures presumably originated from Jakobson's theory, with its fundamental opposition of the metaphoric and metonymic modes of language creation. Nevertheless, Wilson ultimately distinguishes the two figures in terms of Ricoeur's theory of metaphor, and his definition of metonymy consequently inverts Ricoeur's definition metaphor.

Ricoeur does leave a few brief hints in his *The Rule of Metaphor*. In a section entitled "Metonymy, Synecdoche, and Metaphor," Ricoeur approbates Fontanier's division of figures into "relations of correlation or correspondence," "relations of connection," and "relations by resemblance." As Ricoeur interprets, the first relation amounts to metonymy, the second to synecdoche, and the third to metaphor. Subsequently, Ricoeur collapses the first and second relation (metonymy and synecdoche) in that they "connect objects prior to connecting ideas" (56). Thus, in metonymy and synecdoche, the physical, concrete objects take precedence over any ideal relationships between the objects. As Ricoeur concludes, "in both cases [of metonymy and synecdoche], one object is designated by the name of another; and in both cases, it is the objects [. . .] that enter into a relationship" (57).

Ricoeur contrasts – or cites Fontanier as he contrasts – metonymy/synecdoche with metaphor. He writes that metaphor does not contrast objects so much as conventional ideas about objects. Ultimately, Ricoeur claims that "metaphors do not name, but characterize what has already been named [i.e., the tenor]" (57). The examples Ricoeur uses to illustrate this claim are instructive: "the *Swan* of Cambrai," "*consuming* remorse," "courage *craving* for peril and praise," and "his *seething* spirit" (57, emphasis original). In each of these examples, Ricoeur sets aside the explicit formula "X is Y" and instead rewrites the metaphor to idealize or sublimate the concrete vehicle. As an idea instead of a concrete object, the evanesced vehicle "characterizes" the tenor. For instance, to take his final example of a "seething spirit," the metaphor phrased explicitly would read something like "His spirit is a hot skillet." As Ricoeur writes it, however, the physical skillet has evaporated to a quality (seething) that characterizes spirit: "his seething spirit."

In so contrasting metonymy/synecdoche with metaphor, Ricoeur implies that the difference between the two classes is that metonymy/synecdoche preserves the vehicle as a concrete object, while the vehicle of metaphor sublimates to an ideal quality that "characterizes" the tenor. Wilson develops Ricoeur's idea further, again offering a causal argument to explain Ricoeur's empirical observation. As Wilson claims, much as the sublimation of the metaphoric vehicle results from the fundamental difference between it and the tenor (readers feel that the posited connection is absurd, and consequently idealize the vehicle as a quality of the tenor), the concrete objectivity of the metonymic vehicle results from a fundamental likeness between it and the tenor. To cite Wilson directly, "the *true* replacement of metaphor contains the element of difference while metonymy's *apparent* replacement does not" ("Ricoeur's Allegory" 296). When the vehicle of a metaphor replaces the tenor, then, a shocking or absurd difference poses a challenge to interpretation. Readers overcome this challenge by distilling the concrete vehicle to a quality that may then be applied to the tenor. However, when the vehicle of a metonymy replaces the tenor, no intrinsic negation or dissonance between the two objects poses any such challenge. The two objects fit or correspond. Accordingly, the vehicle of a metonymy may be retained as a concrete object and not transmuted to a characteristic.

In fine, metaphor signifies likeness in unlikeness. Metonymy, however, to borrow Fontanier's vocabulary, posits a real correspondence or connection between the physical objects, and accordingly compares like to like.[102] Since metonymy compares similar things (whether

[102] I do not mean that this likeness is necessarily ontological. The "likeness" of metonymy may be the sequential correspondence of a cause to its effect, the spatial correspondence of a container to its contents, etc. My point (and Fontanier's and Wilson's) is that metonymy

similar in nature or similar in proximity), the literal meaning of metonymy need not be destroyed. Moreover, since a real and literal connection exists between tenor and vehicle, the vehicle need not be sublimated to make sense of the figure. For instance, to sample Lodge's metonym "keels ploughed the deep," readers understand that "keels" is a metonymical substitution for "ships," much as "deep" is a metonymical substitute for "sea" (Lodge xiii).[103] But since the keel is part of a ship, it follows that the "keels" cross the sea just as much as the ships themselves do. Thus the metonym is true in a literal sense – the keels really do cross the deep -- and no sensation of absurdity drives readers to discard the vehicle in order to resolve the metonymical utterance.

But "keel" relates to "ship" by synecdochic (part-to-whole) metonymy, or by what Fontanier would consider a "relation of connection." What about other forms of metonymy, however, such as Fontanier's "relation of correlation"? For example, take the spatial metonymy of pinning a medal to a person's chest, or of saying that a pot or a kettle is boiling. In the first example, listeners understand that the medal is not literally pinned to the person's chest but to his shirt. Likewise, hearers of the second example understand that the water in the pot boils, not the metal of the pot itself. In both of these examples, one object (chest or kettle) replaces another (shirt or water) based on proximity. Such spatial metonymies make a clear difference between literal meaning and figurative meaning. Literally pinning a medal to someone's chest would be a painful and bloody affair. Likewise, the heat required to make a metal pot literally boil would be far more intense than any kitchen stovetop could muster. All the same, because of the general nature of metonymy, listeners realize that the chest and the pot/kettle literally exist and are

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indicates a real or physical correspondence between objects.

[103] Like Ricoeur and Wilson, Lodge considers synecdoche to be a subset of metonymy. In this example, "keels" is a synecdoche for the entire ship. But since synecdoche is metonymy, Lodge refers to "keels" as a metonymy of "ships."

associated with the shirt and water literally and physically. The very fact that the chest and the pot stand in as proxies for the shirt and the water necessitates their literal and concrete existence. Even more, the chest and pot/kettle must exist literally to understand the figurative sense of the metonymy. It is difficult to imagine water boiling without a pot or kettle to hold it; similarly, it is difficult to imagine pinning a medal to a shirt without a person – and a chest – filling it. Since the purpose of pinning a medal to a shirt is to honor the person wearing the shirt, pinning a medal to an empty shirt would miss the point.

To generalize, then, metonymies do have a figurative sense distinct from their literal sense, but the figurative sense of metonymy does not discard the literal vehicle. Indeed, as we have seen through the examples above, the figurative sense of metonymy requires the literal vehicle. The reason for this is because metonymies associate objects that share a real and literal correlation or connection, whether spatial, causal, or ontological. While the vehicle of a metaphor is inherently unlike its tenor, a literal and actual likeness inheres between the vehicle and tenor of metonymy.[104] The differences between metaphor and metonym may be summed by saying that metaphors compare unlike to unlike, while metonymies compare like to like.[105]

In what follows, I adopt Wilson and Ricoeur's distinction between metaphor and metonymy to assess Hopkins' analogy between spiritual and natural energy. Specifically, I argue that Hopkins' metaphors are more than metaphorical, and posit an actual correspondence

[104] Richards intended the terms "tenor" and "vehicle" to apply to metaphor, not metonymy. In applying these terms to metonymy, I follow Wilson's precedent. See for instance his "Ricoeur's 'Allegory'," page 299.

[105] Following Lodge and Jakobson, Wilson describes the tenor and vehicle of metonymy as "contiguous" instead of "like." "Contiguous" emphasizes spatial proximity, causal sequence, or (as Jakobson and Lodge use the term) psychological association, while "like's" purview is broader, including contiguity but also suggesting ontological correspondence. Since I am setting up a reading of Hopkins' metaphorical metonymy, "like" in all of its senses works well for my purposes in this paper.

between tenor and vehicle. In effect, Hopkins' metaphors verge upon metonymy, and instead of positing likeness between unlike things, identify likeness between like things. More specifically, as I will argue at the end of this chapter, when Hopkins compares God's outstress to electricity and fire, or the soul's energy to magnetism, he does not merely identify an apparent similarity but emphasizes an essential unity. Energy for Hopkins scales the physical to the metaphysical, and the energy of the soul *is* energy, albeit of a highly subtle variety, just as much as the energy of electricity, light, heat, work, or magnetism is energy.

Admittedly, in citing Ricoeur and Wilson, I am applying their theories in a way they would not allow. Ricoeur emphasizes the role of grammatical form in the function of metaphor, and probably would disapprove of confounding metaphor's grammatical form with metonymy's figurative function. Similarly, Wilson takes pains to discriminate metaphor from metonymy, and to distinguish metaphorical symbols from metonymical symbols. My point though is not to interpret Hopkins' poetry from within the perspective of Ricoeur's or Wilson's systems, but to apply insights from Ricoeur and Wilson to Hopkins' poetry. Specifically, I will consider metaphor to imply an underlying difference between tenor and vehicle and metonymy to require an underlying likeness between them. In sum, I argue that when Hopkins compares spiritual force to natural energy, what begins as metaphor often ends as metonymy, and the tension of like-in-unlike transitions to the differentiated unity of like-in-alike. To reword, Hopkins' metaphorical figures often stretch rhetorical convention, and signify not an underlying difference between the things compared, but an underlying correspondence. In this manner, although the figures he uses may be metaphorical in grammatical form (they consist of a sentence comparing two apparently unlike things) they are metonymical in function, and suggest unity instead of difference. Such an account of Hopkins' metaphor applies particularly well to two of his sonnets, "As Kingfishers Catch Fire" and "God's Grandeur."

4.3 Hopkins' Metonymical Metaphors: "As Kingfishers Catch Fire"

The opening quatrain of Hopkins' sonnet "As Kingfishers Catch Fire" offers one of the most compressed bursts of metaphor in Hopkins' oeuvre.[106] The first line compares kingfishers "catch[ing] fire" in the sun's light to dragonflies "draw[ing] flame" from the same source. The second line compares both kingfishers and dragonflies to stones "tumbled over rim" of a round well. Line three compounds the comparison, adding the additional simile of a "tucked string" telling its name. Line four finishes the salvo, depicting the bow-shaped path of a swinging bell "flinging out broad [the bell's] name."

Structurally, simile and metaphor differ, and the comparisons in "As Kingfishers Catch Fire" should be regarded as similes instead of metaphors. The conventional definition of simile as "a comparison between two unlike things using the words 'like' or 'as'" points out one distinction between the two figures. Beyond this, however, metaphor and simile differ in their grammatical forms. As Raymond Wilson, following Ricoeur, explains, a "metaphor is not a word but a full sentence with definite predication" (294). Stated alternately, a metaphor is a grammatical sentence in which the subject compares to a noun in the predicate, with the copular verb "to be" providing the necessary connection between them. In the case of a metaphorical conceit, the metaphor may extend throughout a poem or passage of prose, but the germ of any metaphor invariably consists of a single grammatical clause in which subject compares to

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[106] To be precise, these comparisons are similes, yet as I discuss immediately below, most critics regard simile as a species of metaphor. My point in this section is to show that Hopkins' metaphor, whether simile or metaphor proper, often suggests a metonymical relationship between the things compared. In other words, Hopkins' metaphor and simile are unusual in that they do not suggest an essential unlikeness between things. Contrarily, they function like metonymy, and posit an underlying unity between objects.

predicate.[107] The verb of the clause marks the turning or coinciding point where the two compared objects meet.

The grammatical structure of simile is much looser, however. With metaphor, the fact that a verb links the two objects together constrains them to appear within a single clause. The comparison of a simile, however, often spans multiple clauses because the comparison turns not on the verb of a clause but rather on an adverb -- “like” or “as.” The adverb can either begin an adverbial phrase within a clause (“I float *like a butterfly*”), in which case the comparison occurs within a single clause; or it may begin a separate adverbial clause (“*As kingfishers catch fire,* dragonflies draw flame”), in which case the comparison spans two clauses.

Functionally, however, simile and metaphor correspond in that they posit an apparent likeness between essentially unlike things.[108] More precisely, as Ricoeur and Wilson make particularly clear, the vehicle loses its concrete subsistence and serves merely to highlight a quality of the tenor. To revisit Ricoeur’s and Wilson’s explanation of metaphor, the reader or hearer of a metaphor perceives the absurdity of directly likening the two objects. Consequently,

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[107] Readers may object that some metaphorical comparisons are implied and not stated. By Wilson’s account, these comparisons are metaphorical symbols, not metaphorical figures in a strict grammatical sense. (See my discussion above of Wilson’s distinction between symbol and figure.) While this may seem like a dodge, Wilson’s point is that if a metaphor is stated explicitly, it will invariably take the form of a grammatical sentence comparing subject to predicate. Similarly, readers may object that a metaphor need not take the form of a clause at all. To cite an example from Ricoeur, the expression a “mantle of sorrow” is a metaphor, but it does not form a clause. Admittedly, this is so, but the expression implies the clause “sorrow is a mantle” (*Interpretation Theory* 50). Still other readers may object that some metaphorical expressions contain embedded clauses, and consequently do not consist of a single clause. Complex grammatical subjects, for example, often consist of a clause functioning as the subject of a larger clause. While this may be, the clause that expresses the comparison -- the clause upon whose copular verb the comparison hinges – also forms the metaphor proper.

[108] According to Ricoeur’s history, Aristotle first posited simile as an instance of metaphor (*The Rule* 24-5). Other rhetoricians “from Quintilian onwards” reversed Aristotle’s classification and made metaphor a subset of simile (25). Ricoeur’s sympathies seem to lie with Aristotle in perceiving simile as a “developed” metaphor (25). Taxonomic hierarchies aside, Ricoeur’s history evidences the longstanding association of the two tropes.

the hearer strips the vehicle of its objectivity and allegorizes it to represent a quality of the tenor. Tenor and vehicle are essentially unlike as real objects, and the connection between them takes the form of an abstracted quality. In sum, because hearers perceive the "absurdity" of the copular link between subject and predicate, they "[reject] the literal" identification of the two nouns and substitute an ideal or semantic relation (Wilson 295). In this relation, the objectivity of the tenor persists while that of the vehicle evanesces.

Simile functions similarly, with the exception that it never posits the relation as literal. The fact that the comparison hinges on the adverbs "like" or "as" instead of the copula "to be" primes hearers to expect an allegorical or abstracted relation. For simile and metaphor alike, then, objects compared are essentially distinct, and in order for the comparison to hold, the concrete objectivity of one of the objects must be superseded or allegorized. The quality that links vehicle to tenor is neither essential nor physical, and in the comparative relation the reality or presence of the vehicle is exchanged for an abstraction.

Ricoeur's and Wilson's analyses highlight several idiosyncrasies of Hopkins' tropes in "As Kingfishers Catch Fire." First, the welter of comparison confounds distinction between tenor and vehicle. The first four lines feature five objects, and assigning primacy to one object over the others disrupts the poem's logic of serial comparison. Second, the sonnet compares objects as they perform an essential activity of "selving." The sonnet's emphasis on selving forbids abstraction, and underscores the concrete reality of each of the five objects within the serial comparison. Third, in comparing objects as they "selve," the sonnet compares not so much the objects themselves but the objects' action of selving. Effectively, the sonnet compares selving with selving. This tautology emphasizes the objects' underlying connection, and further confounds distinction between tenor and vehicle. Fourth, the sestet of the sonnet insists upon a unity that legitimates -- essentially and not abstractively – not only the comparison among the first five objects, but also the likeness of all things in creation. Thus Hopkins' metaphors are more than metaphorical, and in positing a link between things, the sonnet points not to an idealized or abstracted connection but a real and vital identity that inheres in the nature of things themselves.

Part of what confounds allegorization is that each of the compared objects "does one thing and the same" (5). The first of Hopkins' serial similes – "As kingfishers catch fire, dragonflies draw flame" – shows two creatures exhibiting identical behavior. As a kingfisher flies in the sun, his feathers catch the light and give off an iridescent glare. The glare depends as much upon the kingfisher's keratinous feathers as on the sunlight itself. Accordingly, the glare illustrates a quality native to the kingfisher (at least to its feathers) corresponding with the sun's light to produce a fiery flash. The dragonfly "draws flame" from the sun in precisely the same way. As it flies in the sun, its exoskeleton reflects light in an iridescent display. The hues reflected originate from the sunlight, but the dragonfly's chitinous exoskeleton selectively absorbs some hues while scattering others. The flame that an observer sees depends not on the light alone then but on the properties of the dragonfly's exoskeleton, in addition to the observer's position. Although bird and insect catch the same light, the light scattered depends on the absorptive qualities of the keratinous or chitinous structures that cover the bird's and the insect's bodies.[109]

Thus, the kingfisher and dragonfly charge themselves with the sun's light – they catch its fire or draw its flame – and then release (or reflect) the charge in a spectacularly and

[109] The terms "chitin" and "keratin" are Victorian. The *OED* cites Todd's *Cyclopaedia of Anatomy and Physiology* as the English source of both terms. "Chitin" occurs in volume II of the first edition (1836-9), while "keratin" occurs in volume IV of the same edition (1847-9). See *OED,* "chitin, n." and "keratin, n."

individually-distinctive display. A critical oddity of Hopkins' similes appears here. In selving, the kingfisher's and dragonfly's actions are identical, but their identities are distinct. Thus the sonnet observes unity of action but individuality of being.

Readers of Hopkins' "Kingfisher" poem should remember the poet's interest in spectroscopy. In spectral analysis, the elemental composition of an object may be identified by the wavelengths of light it emits. While kingfishers and dragonflies (and non-luminescent things in general) do not emit light, they do absorb and reflect light. The light absorbed and reflected depends on the chemical composition of the bird feather, insect exoskeleton, or thing. In catching fire, then, the kingfisher's feathers absorb and reflect light in a specially identifiable pattern, and the iridescent flash that results marks an essential quality of the kingfisher.[110] So for the dragonfly drawing flame. In both cases, light stems from the same source, but is differently filtered by the living things it illuminates. The kingfisher's fire and the dragonfly's flame signify special being, then, and suggest the unique essence of two distinct forms.

Grammatically, one might say that the first clause of the simile ("As kingfishers catch fire") contains the comparative adverb and serves as the vehicle of the comparison, while the second clause ("dragonflies draw flame") serves as the tenor. Functionally, however, since each clause expresses the same thing – light transforming into specially distinctive iridescence -- it makes little sense to prefer the one clause as more essential or concrete than the other. Another alternative persists, however. Potentially, the mechanics of iridescence could be the poet's focus, and both the dragonfly and the kingfisher could be allegories for the properties of reflected light. In other words, while the poem ostensibly contrasts the actions of the dragonfly and the

[110] Interestingly, the spectral properties of bird feathers and insect exoskeletons still excite scientific curiosity. In a recent article published in the Nov. 21, 2011 issue of *Optics Express*, scientists measured the "refractive index of butterfly wing scales" against that of bird feathers.

kingfisher in catching fire and drawing light, perhaps the two are incidental to an investigation of the properties of light. Thus, if the poem is about light and not about creatures, the concrete existences of the kingfisher and the dragonfly may be allegorized away as vehicles for an inquiry of light.

Yet the poem forbids this alternative as well. As the previous analysis suggests, the poem really is about the distinct nature or essence of creatures, and the concrete reality of the creatures may not be superseded. In one sense, both clauses concern light and express the same thing -- the way light, filtered or reflected by matter, illustrates the essential properties of that matter. In another sense, however, the clauses concern creatures and express different things: the first expresses the essential nature of a kingfisher; the second expresses the essential nature of a dragonfly.

The other similes in the poem function similarly, and testify to the special nature of objects as witnessed by the general behavior of energy. The second simile is particularly odd, and performs a synesthetic transposition of sight to sound. Moreover, in this transposition, the second simile appropriates the first simile, annexing it as its first term.

> As kingfishers catch fire, dragonflies draw flame;
> As tumbled over rim in roundy wells
> Stones ring;

Usually, a new simile in a poem will pose two new objects of comparison. But the second simile of Hopkins' poem poses only one new object or class of object – the stones that ring as they are tumbled over the rims of round wells. The stones' ringing compares to both the dragonfly's drawing flame and the kingfisher's catching fire. Thus the first simile, collapsed together, forms the first term of the second simile.[111]

Alternately, the two terms of the third simile, collapsed together, may be viewed as the second term of the second simile. Either way – or perhaps both ways -- the incomplete second simile suggests that comparison spills over between similes. In mathematical terms, the similes of the first quatrain of the sonnet may be represented as follows: $(A \cong B) \cong C \cong (D \cong E)$, where A is the kingfishers catching fire; B is the dragonflies drawing flame; C is the stones ringing; D is the tucked string telling; and E is the swung bell flinging.[112] Such a mathematical arrangement suggests that comparison acts between similes in addition to within them. Whole similes compare to each other much as terms within a simile compare to each other. In effect, the individual similes act as terms within a larger or compound simile. The fragmentary and incomplete nature of the second simile (containing only one term, "C") emphasizes the fact that comparison spills over from one simile to another. Effectually, these compound similes further confound distinction between tenor and vehicle: finding the tenor of a single simile is problematic, but finding the tenor of the entire morass is nigh impossible. In fine, all terms in the quatrain are equally important, and the serial and interlocking nature of the similes preserves the concreteness of each term.

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[111] Hopkins' punctuation signals where one simile ends and the next begins. Commas distinguish objects compared within a simile, and semicolons distinguish one simile from another. Viewed this way, it is evident that the second simile contains only one object or "term" – the ringing stones tumbled over rim in roundy wells.

[112] More specifically, considering the first simile, collapsed together, as the first term of the second simile yields the notation $[(A \cong B) \cong C] \cong (D \cong E)$. On the other hand, considering the third simile, collapsed together, as the second term of the second simile yields $(A \cong B) \cong [C \cong (D \cong E)]$. But since neither notation is more valid than the other, the most proper construction of the quatrain is probably $[(A \cong B) \cong C]; [C \cong (D \cong E)]$.

Hopkins' unusual comparative structure highlights his transition from the behavior of light to the behavior of sound. Much as light expressed the distinctive nature of the kingfisher and the dragonfly, so sound expresses the distinct hardness of stones as they ring against the sides of the well. Again, the general behavior of energy, whether light or sound, attests the special character of objects. James Milroy argues that Hopkins modelled his aural similes in the poem after Max Müller's "Ding-Dong" theory of language (66). By Müller's theory, human language evolved from mimicking the sounds objects make when they are tapped or rapped. Struck sharply, an object "utters" its nature or the idea of its being: stones ring to attest their essential hardness, and likewise wood knocks, mud splats, and wisps whisper. For prehistoric human listeners, the self-distinctive sounds objects made when struck supplied a symbolic basis for language. Accordingly, the roots of human language reach back to a prehistorical moment when speakers began to apply symbolically, to circumstances and events, the sounds objects make when struck.

If Milroy is correct, then once more the poem examines physical phenomena indicative of material composition and structure. Much as the iridescent spectroscopy of the kingfisher and dragonfly expresses their physical composition, so the ringing of stones "tumbled over rim in roundy wells" expresses their physical structure. An object's hardness follows directly from its material make-up: When a hard object is struck, the ringing sound it emits witnesses its internal order and form. An object's signature sound (ringing) suggests its characteristic properties (hardness), which in turn imply its intrinsic material composition. Again, the common behaviors of energy, light or sound, attest the especial nature of objects. As the fire and flame of the kingfishers and dragonfly reveal their internal order, so the ringing of stones discloses their inner constitution.[113]

The third simile extends from the second, again identifying objects by the sounds they produce when struck or stroked: “Like each tucked string tells, each hung bell’s/ Bow swung finds tongue to fling out broad its name” (3-4). With this simile, Hopkins’ speaker turns from natural objects (stones) to human artifacts, stringed instruments and tolling bells. The strings of an instrument are named according to the pitch they play. When a violinist, for instance, “tucks” or plucks a string (*pizzicato*), the tone that issues from the string names the string. An “E” string plays the musical pitch E, an “A” string plays the musical pitch A, a “D” string plays the musical pitch D, and a “G” string plays the musical pitch G. Accordingly, “each tucked string tells [. . .] its name.” Much the same applies for bells, which also may be described according to the pitch a listener hears.[114] A bell’s or string’s pitch depends directly on the frequency at which the

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[113] Technically, sound isn’t a distinct form of energy. Since sound consists of a pressure wave in a medium (air, usually, but potentially water or earth or any other medium), sound is actually an instance of mechanical pressure. All the same, sound is a “form” of energy in that it is an instance of it.

[114] The naming of bells is complex. In an English ring of bells, bells are numbered from highest to lowest. A ring comprises between 3 and 16 bells, depending on the range of the ring and the intervals between individual bells. The highest bell in the ring (bell #1) is called the treble; the lowest toned, the tenor. The intervening bells are designated by the number of their place in the ring.

In addition, the tenor bell is often named according to the pitch or tone listeners hear when it is rung. But bells do not have a single or “pure” pitch. Rather, bells produce multiple pitches, and the tone a listener hears depends as much upon the human sensorium as upon the bell itself. The predominant pitches a bell produces are called “partials,” and most bells have five partials: the nominal (usually unheard), the quint, the tierce, the prime, and the hum. The pitch most listeners hear is usually a synthesis of several of these partials. Ironically enough, this means that the pitch most listeners hear is not actually produced by the bell. Instead, this “virtual” pitch is a psychological compromise the human ear reaches to resolve the competing partials.

Musicians trained in the art of analytical listening, however, may pick out the partials of a bell. Opposed to virtual pitch, the tone these listeners hear is called a “spectral” pitch, and corresponds to the pitch of one (usually the most dominant) of the bell’s partials.

instrument vibrates. Since the rate of an instrument's vibration depends on its material makeup, as well as its shape, length, and volume, then once more sound reveals the physical composition and structure of the object. In terms of the simile, just as a string's material structure determines the sound that it makes, so a bell's material structure determines the sound that it makes.

In all, Hopkins' similes repeatedly compare how energy expresses, in a manner perceptible to the senses, the innate constitution of objects. In so doing, the similes emphasize the distinct material forms of creatures and objects. The first simile compares the way light energy reveals the composition of kingfishers' feathers with the way that light energy reveals the composition of dragonflies' carapaces. The second simile likens how light translates keratin and chiton as a flash to the eye with how sound translates stone as a ringing to the ear. Finally, the third simile contrasts the way a string's physical vibration yields its distinctive pitch with the way a bell's physical vibration yields its distinctive pitch. In each simile, the manner in which energy acts on one object to reveal its material structure to the senses compares with the manner in which energy acts on another object to reveal its material structure to the senses.[115]

As the previous sentences suggest, Hopkins' similes border on tautology. If, as classical grammarians have written, a simile compares two unlike objects; and if, as Ricoeur and Wilson

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I have been unable to determine whether Hopkins knew of the difference between virtual and spectral tones. Hopkins' knowledge of bells (campanology) and bell ringing (tintinnabulation) is not clear from his biographical materials. If Hopkins knew the musical mechanics of bells, then presumably his poem concerns spectral pitch as opposed to virtual pitch. Given the long history of campanology, and given Hopkins' interest in church architecture, bell towers, and music generally, I would be surprised if Hopkins was ignorant of the subject, but this is merely my surmise. At any rate, Victorian physicists made substantial contributions to the theory of bells, most notably Lord Rayleigh's "On Bells" (1890) and Hermann Helmholtz's *On the Sensations of Tone* (German edition, 1863; English edition, 1875).

[115] But see below. While readers understand that light illuminates the kingfisher and the dragonfly, and that the stone, string, and bell emit sound only if they are tumbled or "tucked," Hopkins consistently treats the objects themselves as active. For Hopkins, being is active and not passive.

argue, the vehicle of a metaphorical comparison evaporates into an idea or quality, then it is possible to question the extent to which Hopkins' similes function as similes. As the previous paragraph implies, the similes do not compare objects so much as they compare actions. In both halves of all three similes, a form of natural energy acts upon an object to make its intrinsic form sensuously apparent to an observer. Since the two actions of each simile are congruent if not identical, Hopkins' similes compare like to like. Moreover, with the objects themselves in view, Hopkins' similes do not sublimate from the concrete to the abstract. Instead, they emphasize physical phenomena which "tell" or "fling out broad" the innate material form of created things.

These two characteristics – Hopkins' comparison of like to like, and Hopkins' refusal to abandon the concrete particular – inform the second quatrain of the octave:

> Each mortal thing does one thing and the same:
>
> Deals out that being indoors each one dwells;
>
> Selves – goes its self; *myself* it speaks and spells,
>
> Crying *What I do is me: for that I came*. (5-8).

At this point, I should note that above when I ascribe agency to the various forms of energy that act upon the objects, I depart from Hopkins' language. Consistently, Hopkins ascribes agency to the objects themselves. In the words of the poem, light does not act upon the kingfishers; the kingfishers "catch fire." The agency of the object is even more pronounced with the dragonfly, which "gathers flame." Similarly, the string "tells" and the bell "flings out broad its name." For Hopkins, the object expresses its agency in being what it is. Being is not passive but active, and the forms of energy that act against an object merely translate its activity of being to a form perceptible to the senses. To be precise, then, the actions in the poem that are being compared are not the actions of energy but the actions of creatures and things. Each object in the poem “speaks and spells” its distinct being, yet in doing so performs an activity identical to every other object in the poem, which also speaks and spells its being. This unity of action suggests an underlying unity of being that reconciles distinctions between objects. As Hopkins’ poetic speaker says, in “dealing out” that unique being which “indoors in each one dwells,” “each mortal thing does one thing and the same.”

This action, individually distinctive yet collectively univocal, provides an initial clue to the sestet, and also explains Hopkins’ unusual similes. If an underlying unity underwrites the distinct natures of created things, or if an ontological connection legitimately exists between things, then for Hopkins, comparisons express the genuine unity among created things. Hopkins’ metaphors or similes, then, need not allegorize or banish the concrete vehicle, because the link between vehicle and tenor inheres not merely in the observer’s mind but in the nature of the things themselves. Opposed to Ricoeur, who perceived metaphor as a surface similarity between two inherently dissimilar things, Hopkins perceives metaphor as a surface similarity that points to a deeper ontological unity.[116] Comparisons between things are warranted because the things actually correspond, and the phenomenal linkages discovered by metaphor act as signs pointing to a deeper noumenal correspondence.

Hopkins’ sestet justifies the similes of the octave, and identifies the unifying commonality inherent within created things – Christ:

> I say more: the just man justices;
>
> Keeps grace: that keeps all his goings graces;

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[116] My claim about a “deeper ontological unity” underwriting the distinct forms of created things is nothing new in Hopkins’ scholarship. After James Cotter’s *Inscape*, this claim amounts to a truism. What is new about my claim is that I apply it to Hopkins’ metaphor. To my knowledge, the metonymical function of Hopkins’ metaphor has not been addressed by any critic. Later in this chapter, I will apply my discussion of Hopkins’ more-than-metaphorical metaphors to his metaphors of spiritual stress.

> Acts in God's eye what in God's eye he is ---
>
> Christ. For Christ plays in ten thousand places,
>
> Lovely in limbs, and lovely in eyes not his
>
> To the Father in the features of men's faces.

As the kingfishers, dragonfly, stones, string, and bell reveal their identity through action, the "just man" also has a self-distinctive and self-identifying activity. The just man "justices." Justicing apparently applies to a person's individual actions, since the parallel synonym of justicing, "keep[ing] grace," applies to individual action or "goings": "the just man justices;/ Keeps grace: that keeps all his goings graces." In the octave, "going" ("going it self") is identified with "selving." So too in the sestet, the phrase "all his goings" likewise describes the just man's process of selving. If keeping grace and justicing characterize "all [one's] goings," then these synonyms likewise apply to the actions by which one "selves" or "deals out that being indoors each one dwells."

But though "justicing" applies to the individual actions a person takes, it also characterizes the collective behavior of all just men and women. As in the octave, where the creatures' acts of selving are individually distinctive at the same time that they are collectively identical, so in the sestet, the individual's justicing marks his distinct behavior all the while it identifies him with others. In other words, though the "goings" of one just man may be distinguished by circumstance from the "goings" of another just man, a single identity underlies all just "goings."

In fine, all just men and women participate in a common identity. Given Hopkins' religious beliefs, this identity is not surprising: just men and women "[act] in God's eye what in God's eye [they are]/ – Christ." In so saying, Hopkins extrapolates the Pauline metaphor likening individual Christians to parts of Christ's body.[117] As Hopkins' poetic speaker continues, "For Christ plays in ten thousand places,/ Lovely in limbs, and lovely in eyes not his/ To the Father through the features of men's faces."

In naming Christ, these lines utter the Identity underlying the similes of the octave as well as the metaphor of the sestet. Admittedly, the similes of the octave entertain a different sort of existence than the metaphor of the sestet. The octave's similes address physical objects and require a material consonance between things in nature, while the sestet's metaphor addresses human behavior and requires a moral consonance between the actions of just men and women. But for Hopkins, Christ underwrites creation materially and morally. As several critics have shown, Hopkins conceived of matter as a direct consequence of Jesus' Great Sacrifice. In Hopkins' poetic mythos, matter originates from Jesus going "forth from the Father [. . .] to give God glory and that by sacrifice, sacrifice offered in the barren wilderness [of matter] outside of God" (*Sermons* 197). Even more, not only is the material world implicit with Christ in that it affords him a sphere in which to offer his sacrifice, it is also instinct with his nature. Much as Christian tradition identifies Jesus as the "Word" or "Image" of God, Hopkins writes that "God's utterance of himself in himself is God the Word [Jesus], outside himself is this world. This world then is word, expression, news of God" (*Sermons* 129). Accordingly, just as Jesus is the "express image of [God's] person," the world is an image of God as well (Hebrews 1:3). Given that Jesus

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[117] See, for instance, I Corinthians 12:12-19,27 – "For as the body is one, and hath many members, and all the members of that one body, being many, are one body: so also is Christ. For by one Spirit are we all baptized into one body, whether we be Jews or Gentiles, whether we be bond or free; and have been all made to drink into one Spirit. For the body is not one member, but many. If the foot shall say, Because I am not the hand I am not of the body; is it therefore not of the body? And if the ear shall say, Because I am not the eye, I am not of the body; is it therefore not of the body? If the whole body were an eye, where were the hearing? If the whole were hearing, where were the smelling? But now hath God set the members everyone of them in the body, as it hath pleased him. And if they were all one member, where were the body? [. . .] Now ye are the body of Christ, and members in particular."

provides the world with its structure and being, the world takes form as an image of Jesus' Image. Created things bear Jesus' stamp or "mark" in their very natures, and God's Nature underwrites all nature.[118] As J. Hillis Miller describes Hopkins' mythos,

> To say that all things are created in Christ means seeing the second person of the Trinity as the model on which all things are made, nonhuman beings as well as men [. . . .] To see things as created in Christ means seeing Christ as the Word, the Being from whom all words derive [. . . .] Christ is the perfection of human nature, but he is also the perfection of birds, trees, stones, flowers, clouds, and waterfalls. He is, to give the Scotist term for this concept, the *natura communis*, the common source who contains in himself all natures. (313)

Though the octave of the sonnet concerns material objects instead of moral agents, the underlying unity of octave and sestet is Christ. If Christ is "the common source who contains in himself all natures," then he contains the natures of kingfishers and dragonflies, and matter itself – stones, strings, and bronze bells – takes its nature and being from Christ's Being. Accordingly, though each material object "goes its self" and "speaks and spells" itself, it also speaks the underlying Nature of its being, a Nature it shares with every other being. Within the material world as well as the moral sphere of human action, "Christ plays in ten thousand places/ Lovely in limbs, and lovely in eyes not his."

Hopkins' metaphorical figures emphasize this tension between an object's unique selving from other objects and its collective correspondence with other objects. Because of Hopkins'

[118] "Mark" is one of Hopkins' favorite terms. It is a pun, and identifies nature with Christ's Great Sacrifice in two ways. First, created things were made by Christ as part of his procession out of the Trinity into the wilderness outside God. Accordingly, matter and material objects bear Jesus' maker's "mark," or the impress of his design. Second, fallen nature is redeemed by Christ's sacrifice on Calvary and hence is identified with the stigmata, the "marks" of crucifixion.

ontology, two qualities distinguish his metaphors from Ricoeur's theoretic description. First, Hopkins' metaphors retain the concreteness or material substance of both objects compared. Hopkins' metaphors do not need to empty the vehicle of concrete existence since his comparisons rely not on an allegorical but a real connection between the two (or three or four or five) things. Second, Hopkins' metaphors indicate identity or correspondence instead of difference, while for Richards and Ricoeur, difference epitomizes metaphor. For Ricoeur, and for Lodge and Wilson after him, difference demarcates the territories of metaphor and metonymy. As Raymond Wilson summarizes his theoretic predecessors, "both metaphor and metonymy *appear* to operate through replacement; however the *true* replacement in metaphor contains the element of difference while metonymy's *apparent* replacement does not" (296, italics original to text). In other words, the hearer of a metaphor "replaces" or banishes the concrete vehicle in favor of the tenor because tenor and vehicle are essentially different, and a literal connection between them is absurd. Metonymy, however, operates by semantic consonance instead of dissonance. While one term may replace another, the selected term does not banish the replaced term. Rather, the latter term preserves the former in the mind, and even suggests it to the mind. Given the spatial, causal, or proportional correspondence between the two terms, the one suggests the other.

If difference marks metaphor (or simile), and consonance marks metonymy, then by Ricoeur's, Lodge's, and Wilson's definition, the figures in "As Kingfishers Catch Fire" may be similes formally but they are metonymies functionally. Crucially, tenor and vehicle share in a common ontological substratum – Christ – and correspond to each other as parts within a larger whole. Thus, the apparent similarity posited by the metaphor points to an actual correspondence between the things themselves, and Hopkins' metaphor consequently lacks the absurd dissonance that compels readers to empty the vehicle of concrete objectivity. Thanks to the vehicle's actual, literal, *physical* correspondence to the tenor, a correspondence that exists in reality and prior to the metaphorical relation, the vehicle persists as an object in its own right, and compares to the tenor as another part within the larger, interrelated whole.

Such, I argue, is the nature of Hopkins' metaphor in "As Kingfishers Catch Fire." Yet since Hopkins' other poems similarly express Christ's universal presence, and likewise stem from his poetic mythos of the Great Sacrifice, I propose taking "As Kingfishers Catch Fire" as a primer for Hopkins' metaphor generally. Accordingly, in the next section of this chapter I will read "God's Grandeur" in a similar fashion as I read "As Kingfishers Catch Fire." Specifically, I will consider the relationship between tenor and vehicle, or between God's grandeur and the energies of the mundane world, in the poem's metaphorical conceit. Much as the tenor and vehicle in "As Kingfishers Catch Fire" correspond as parts within a larger whole, so in "God's Grandeur," God's outstressed power and the powers of nature correspond as forms of energy within Hopkins' integrated cosmos.

4.4 Outstress and Energy: Hopkins Integrated Cosmos

As we have seen in "As Kingfishers Catch Fire," the correspondence among creatures themselves and between creatures and Christ stems from the Great Sacrifice. So too does the correspondence, in poems like "God's Grandeur," among forms of energy and between energy and outstress. In his devotional writings, Hopkins defines the Great Sacrifice as the origin of all creation, of the metaphysical (or aeval) realm of angels and spirits as well as of the physical realm of stars and planets and bodies of matter. Hopkins' universe includes these realms equally, and neither is more native or proper to the created world than the other. Likewise, God's creative energy (his "outstress") circulates generally, permeating both realms.

According to his notes on the Long Retreat of 1881, creation or the cosmos is a means to an end, a measure to furnish the Son a place and a body for sacrifice.[119] In Hopkins' Trinitarian theology, "the Son of God [goes] forth from the Father [. . .] in the eternal and intrinsic procession of the Trinity" (197). Thus, the Father generates the Son in eternity, and the Son is coeval and co-eternal with the Father. So far Hopkins accords with mainstream Catholic doctrine. But Hopkins, drawing from Duns Scotus, extends the Son's trajectory outside the Trinity with his question "Why did the Son of God go thus forth from the Father not only in the eternal and intrinsic procession of the Trinity but also by an extrinsic and less than eternal, let us say aeonian one? To give God glory and that by sacrifice" (197). One might say that Hopkins attributes to the Son an affective momentum. Given a motion forth from God within the Trinity, the Son carries this motion outside the Trinity. The motion itself? Love for the Father and the desire to "give God glory and that by sacrifice."

Accordingly, the Son goes forth into "the barren wilderness outside of God" to offer sacrifice (*Sermons* 197). The wilderness outside of God is presently barren because it has not yet been filled or created. However, as he journeys into the wilderness to offer sacrifice, the Son populates the wilderness, and forms and fills the barren wilderness with life. In Hopkins' words, Christ "create[s] angels to be his company, lambs to follow the Lamb" (197).[120]

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[119] Most Christians see creation as the cause of Christ's incarnation and sacrifice. By this view, Christ was born to die in order to redeem his fallen world. However, as Christopher Devlin explains, Hopkins "saw creation as dependent upon the decree of the Incarnation, and not the other way around" (109). Jesus created the world so that he might enter it, take on material form, and offer himself as a sacrifice to the Father. Devlin also notes that Hopkins believed Jesus' sacrifice was originally intended to be bloodless. The original point of sacrifice was not to cleanse sin, since sin did not exist. Rather, the point of sacrifice was for the Son to express his love for the Father through voluntarily self-descent. To humble himself by taking on material form was sufficient – blood was not required.

[120] Hopkins distinguishes between the Son in eternity and Christ in the world. Essentially, Christ is the incarnate Son. Note that Christ's incarnation dates not to his birth in Bethlehem. Rather, in

As Christ progressively incarnates himself in the barren wilderness, he creates creatures according to the nature he takes on.[121] When Christ incarnates himself within the aeonian or angelic realm, he takes on an angelic nature and creates the angels to be as he is. Similarly, when Christ presses into the wilderness beyond the aeonian realm and into the physical realm, he further incarnates himself as a being with a physical and material body. Accordingly, he creates more creatures to be as he is now: physical and material. Thus Christ's creatures partake of his nature in that what they are is what Christ made himself to be. To rephrase, their nature (physical or angelic) is the nature that Christ originally made for himself, and only afterwards extended to them. Thus, the angelic order and angelic beings originate from the nature that Christ made for himself to be; likewise, the material order and material beings originate from the nature that Christ made for himself to be. In this way, as the "Kingfishers" sonnet shows, Christ is the substratum of all existence, and underwrites the nature of every individual thing. His incarnate nature is expressed through the individual natures of all things.[122]

Christ's creates his creatures to participate in his Sacrifice. Hopkins writes, "they were to take part in the sacrifice and he was to redeem them all" (197). In this sacrifice, however, neither

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the sense of time, his incarnation is incremental, and began with or before his creation of the angels (the aeonian order) when he first ventured into the wilderness outside God. In this sense, Christ's birth as a baby is the culmination of his incarnation, not the beginning of it. Of course, in God's "order of intention," Christ is eternally incarnate, since the will of God was always for him to be so (*Sermons* 196).

[121] In terms of literary genre, Hopkins' Great Sacrifice narrative might be classified as a Scholastic romance. Several of Hopkins' sermons and poems describe Christ as a chivalric Hero. Furthermore, Christ's incarnation takes the form of an episodic quest, the climax of which is sacrifice and the resolution glory. Nor is the Hero without companions, for he "create[s] angels to be his company" (*Sermons* 197).

[122] Granted, Hopkins composed his notes on the Great Sacrifice during the Long Retreat of 1881, while he composed "As Kingfishers Catch Fire" several years earlier, most likely in 1877 (MacKenzie, *Reader's Guide*). As such, the Great Sacrifice may have developed from the intimation of the sonnet and other poems like it. At any rate, the sonnet and the Great Sacrifice concur in establishing Christ as the substrate of all created beings.

Christ nor his creatures were intended to die. Rather, the Sacrifice consists in an act of love, a voluntary humiliation "which would have taken place in one form or another whether or not there had been any sin" (Devlin 109). As originally intended, Christ's humiliation involved no further debasement than that the creator would take material form and become his own creature, conformable to the rest of his creatures. Yet beside humiliation, the Sacrifice also entails exaltation, for Christ and his creatures. In humbling himself, Christ glorifies the Father, who then glorifies his Son for his supreme act of supererogatory obedience. Likewise, the creatures themselves are glorified in Christ, and in participating with Christ in his voluntary humiliation, are elevated with him in his exaltation. Thus, by participating with Christ in his Sacrifice, the creatures become God the Son's companions and co-participants. Ultimately, the Great Sacrifice is a mechanism of cosmic uplift, and has a two-fold purpose: to give God glory through self-sacrifice, and to elevate God's creatures to God-worthiness. Hopkins writes,

> They were to take part in the sacrifice and he was to redeem them all, that is to say / for the sake of the Lamb of God who was God himself God would accept the whole flock [. . .]; for redeem may be said not only of the recovering from sin to grace [. . .] but also of the raising from worthlessness before God (and all creation is unworthy of God) to worthiness of him, the meriting of God himself, or, so to say, godworthiness." (*Sermons* 197)

Effectively in the Great Sacrifice, God lowers himself to his creatures, and then lifts his creatures to himself.

But the sacrifice is progressive, and trends downward or outward from God before it returns upward or inward to him. After creating the aeonian realm of the angels, Christ moved further into the wilderness, intending to create the physical world of matter. At this further humiliation, Hopkins writes, Satan rebelled: "But when Satan saw the mystery and the humiliation proposed he turned back and rebelled" (197). Thus the Great Sacrifice explains the origin of the cosmos, spiritual and material, as well as the origin of sin.

The Great Sacrifice also explains the origin of energy. At each stage of the Great Sacrifice – at Christ's incarnation within the aeonian realm and his creation of the angels; at his incarnation within the physical realm and his creation of material objects and beings; at Christ's incarnation as a baby in Bethlehem; at his ultimate sacrifice on Calvary; and finally in his Real Presence in the Eucharist – Jesus introduces "stress" to the world, or "outstresses" power from himself within the world.[123] The ultimate unity of natural energy and spiritual force stems from this "outstress." Outstress, as Hopkins defines the term in his notes to Great Sacrifice, is an exertion of God's power "outside himself" (*Sermons* 197). Since Hopkins held God to be infinite, it may seem odd for Hopkins to conceive of anything outside God, but Hopkins follows Christian orthodoxy in holding nature, creation, or the cosmos (these terms are perfect synonyms for the devout Hopkins) as external to God in the sense that nature does not partake of God's being.[124]

Outstress, like many of Hopkins' key terms, shuttles between material and energetic signification. Thus, the expression "an outstress" or "the outstress" applies equally well to the created object as it does to the creative power by which the object came into being. Since the object results from the power, Hopkins applies the same phrase to object and power alike,

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[123] The difference between outstress and instress appears to be a matter of perspective. God or Jesus outstresses power from himself. The power outstressed from God is instressed into creation. For a somewhat expanded description of this, see below.

[124] Matter (and spirit) partakes of Christ's created being, since matter (and spirit, too) is the nature that Christ created for himself to take on. However, creation does not partake of the nature of the Trinity. Christ, containing both natures in one within himself, mediates between the Trinity and creation.

presumably to emphasize the causal relation between them. When using this term, it should be remembered that "outstress" signifies being or energy outside and apart from God's nature. Given that created things are outstresses from God, they are distinct and separate from his being. Similarly, the energy that God outstresses to his creation is just that – energy resident in creation that God separates or stresses outwardly from himself. Accordingly, when Hopkins speaks of outstress, he does not mean the infinite and eternal power of God at rest beyond time and the cosmos. Rather, he means energy that originates from God but has been stressed outwardly or severed in some way from the Trinity to act within time and within creation.[125]

Hopkins' sonnet "God's Grandeur" establishes the analogy between God's "grandeur," or his outstress in creation, and the various mundane forms of energy within creation.[126] According to the well-known opening lines of the poem, "The world is charged with the grandeur of God./ It will flame out, like shining from shook foil." The imagery of "charged" and "flame out" possesses metaphoric resonance in suggesting electricity and light, but the first grammatical metaphor in these lines occurs with the predicate "like shining from shook foil."[127] Not only is this metaphor the first in the poem, it is the central figure of the poem and poses an interpretive crux. If this figure is a metaphor functionally as well as formally, then it posits a surface similarity between God's grandeur and the "shining" light, all the while preserving an essential

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[125] See *Sermons,* 197 and 129. Both passages emphasize that outstress is an application of power "outside" of God. In describing the Great Sacrifice, Hopkins equates "outstress" with an "intention [. . .] of God outside himself" (197). Similarly, in his meditation on the meaning and purpose of the world, Hopkins emphasizes that "God's utterance [. . .] *outside* himself is this world" (129, my emphasis).

[126] For now, I will assume that grandeur is a synonym of outstress. My reasons for doing so will become apparent when I discuss the sonnet's sestet. Given that God's grandeur and the Holy Spirit's creative "brooding" have an identical effect in that they charge and restore the world, God's grandeur should be considered as a manifestation of his creative power, and hence an instance of his outstress.

[127] Technically, "like" makes the figure a simile. Again, however, simile is a subset of metaphor.

distinction. On the other hand, if this formal metaphor drifts into functional metonymy, it suggests an essential unity between grandeur and light, and by extension between God's outstress and the energies of the natural world.

Grammar provides the first clue. Pertaining to the sonnet's opening lines – "The world is charged with the grandeur of God./ It will flame out like shining from shook foil" -- various critics have observed that the antecedent for "it" is unclear, and that the pronoun "it" may refer to either "the world" or "the grandeur of God."[128] Unless Hopkins lapses here (hardly conceivable for such a painstaking poet), the ambiguous antecedent poses an initial connection between divine grandeur and the "charged" world. This connection between divine and natural energy becomes more explicit in the rest of the second line. If "it" refers to "world," then the world, charged by God's grandeur much as a battery is charged by an electrical current, breaks forth in flames and flashes of light (or "lightning," according to an earlier draft of the poem). However, if "it" recalls "the grandeur of God," then the grandeur of God manifests in physically energetic form, much as fire and light are physically energetic forms. In short "world" and "grandeur" express one another through the medium of energy. If the world flames and shines, it does so because it has been energetically charged by God's grandeur. If grandeur flames and shines, then in doing so it expresses its nature as consonant with the energies of the natural world.[129]

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[128] "World" has a grammatical advantage over "grandeur" in that "grandeur" is an object of a prepositional phrase ("*with* the grandeur of God"). Nevertheless, in actual English speech and writing, pronouns frequently refer to objects of prepositions. "Grandeur," on the other hand, has a positional advantage over "world" in that it is the closest noun to the pronoun "it." Given Hopkins' love of double meanings and uncertain syntax, it might be best to assume that both "world" and "grandeur" are intended as alternate antecedents.

[129] And also consonant with forms of energy closely studied by Victorian physicists. The line "it will flame out, like shining from shook foil" evokes a number of forms of energy: heat (of the flame), chemistry (the flame's combustion of oxygen), electricity (an earlier draft of the poem read "like lightning from shook foil"), and light ("shining"). From the 1790s through the 1840s, physicists like Rumford, Davy, Orsted, Faraday, Mayer, Joule, and others indicated the

Yet while the first two lines establish the analogy between God's outstress (his grandeur) and natural energy, they do not define the nature of this analogy. At first blush, this analogy may appear entirely metaphorical. While the Bible tells of instances when God's presence takes energetic form -- storms, lightning, columns of fire, etc. – such miracles are rare and intermittent. Likewise, the sonnet itself forbids accounting for God's grandeur solely through miracle, treating the grandeur of God as an ongoing and ever-present "charge." If "it" in the third line ("it gathers to a greatness") refers to "grandeur," then God's grandeur gradually but steadily accumulates, drip by drop "like the ooze of oil/ Crushed." From this, Hopkins conceives of grandeur primarily as a gathering of everyday grace, not an explosive dam-break of miracle. Importantly, while the verbs in the octave of the poem describing human activity are frequently present perfect ("have trod," "is seared," "[is] bleared" "[is] smeared"), denoting past actions with present consequences, the verbs in the sestet stemming from the Holy Spirit's activity are present tense ("lives," "springs," "broods"), and imply continual action in the present. As such, the "charge" of God's grandeur includes miracles of flame and lightning and light, but more often attests God's continual and everyday presence in the world.

Yet although God's grandeur does not usually appear as literal flames and lightning and light, the subsequent lines of the poem nevertheless treat it as an energy active within and necessary to the physical processes of the cosmos. The analogy of the poem is not merely or "just" metaphorical. Instead of comparing two dissimilar things, as in metaphor or simile, the analogy of the poem associates God's grandeur with other forces in nature that are similarly energetic. Accordingly, the poem's analogy operates not by metaphor but by metonymy, and

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interconvertibility of these forms of energy. In the 1850s, Thomson, Clausius, and Rankine articulated their predecessors' findings as a coherent theory, the central tenets of which found expression as the laws of thermodynamics.

grandeur, light, electricity, magnetism, heat, and work are associated because of an underlying connection or unity.[130] In short, God's grandeur, or his "outstress" in creation, is not *like* energy. It *is* energy, energy in its subtlest and most pervasive form in creation.

Hopkins' metonymy gathers force throughout the poem. In the first quatrain of the octave, his ambivalent antecedents "the world" and "the grandeur of God" provide an initial hint. If both "the world" and "the grandeur of God" are energetic systems, then either may be said to "flame out, like shining from shook foil." Yet while the first quatrain oscillates between the energies of outstress and the natural world, the second quatrain addresses yet another application of energy, namely humanity's ability to harness natural energy in industrial production:

> Generations have trod, have trod, have trod;
> And all is seared with trade; bleared, smeared with toil;
> And wears man's smudge and shares man's smell: the soil
> Is bare now, nor can foot feel, being shod. (5-8)

Echoes of the first quatrain reverberate in this second. The natural energies of fire and heat reappear in the world "seared," "bleared," "smeared," and "smudge[d]" by industrialized trade. These images remind readers of pollution from coal and wood fires that heated factory steam engines. Thus the flames of "the [natural] world" and "the grandeur of God" in the first quatrain become the coal fires and sooty "smudge" of the second. If God's grandeur charges nature in the first quatrain, industrial mis-production denudes it in the second. The world, so fecund at the octave's beginning, "is bare now" at its end (8). Tragically (the word is not too strong when speaking of Hopkins' feeling for the "sweet especial scene[s]" of nature), trades "sears" both the landscape and the human conscience. While the "soil is bare," the sole is shod,

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[130] See my earlier discussion of Hopkins' "strict" metonymy. Again, Hopkins' metonymy functions according to Fontanier's "relationship of connection."

and human sensibility, blunted and estranged from nature by the luxuries of industrial production, cannot feel its guilt.

If the first quatrain considers the ways God's outstress "charges" the natural world, the second considers the ways industrial society "spends" (or misspends) this charge (1, 9).[131] Together, in reducing divine, natural, and human activity to the substratum of energy, the first and second quatrains correspond, and instantiate the underlying unity of energy within creation. Much as the energies of the natural world correspond with God's grandeur in the first quatrain, so in the second quatrain industrial power corresponds -- in one sense -- to God's grandeur in that it also is a manifestation of energy. The irony in the second quatrain stems from a juxtaposition of the divine origin of industrial power, the "grandeur" of God that charges the natural world and that is subsequently harnessed by industry, and the debased end of industrial society -- the filth and "illth" that results from industrialized production.[132] As Hopkins writes in another sonnet, "the inmate does not correspond": the human "inmates" of industrial society, gifted with power from Nature and ultimately God, fail to correspond with their gifts, selfishly squandering them and polluting their world ("The Valley of the Elwy" 11).

Yet the second quatrain is not mere moralization. In context with the first quatrain's depiction of the world as a "charged" battery, the waste and misspending of this charge in the second quatrain instances a peculiarly Victorian anxiety concerning the implications of

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[131] As various critics, most notably Norman MacKenzie, have noted, "charge" is a pun. The world is charged by God's grandeur as a battery is charged by an electrical current, but the world is also charged as a subordinate is charged by a superior. The word charge simultaneously expresses a quantum of energy and a quality of obedience. In essence, to squander the provision (the "charge" of energy) is to disobey the command (the "charge" to duty).

[132] "Illth" is Ruskin's term from *Unto this Last* (105). Ruskin uses it as the antonym of "wealth." For Ruskin, "Illth" does not mean poverty. Instead, if "wealth" describes riches that tend to life (grain, bread, practical clothing, lumber and housing materials, etc.), then "illth" describes riches that tend to death – luxury goods and systems of production that enslave the worker to enrich proprietors and consumers.

thermodynamics' second law. According to the first law of thermodynamics (see chapter 1), if energy can be neither created nor destroyed, then the energy within a closed and isolated system must be constant. Energy can change form (from electricity to magnetism as Oersted found; from magnetism to light as Faraday found; or from electricity, magnetism, and work to heat as Joule and others found) but it cannot be annihilated. However, the second law holds that while energy cannot be destroyed, it progressively becomes less available for use in a closed system. Given that energy disperses, a system's energy diffuses evenly over time. In that system's final state, its energy will be too diffuse and too uniform to be used. If the physical universe is a closed system, then the second law predicts that at some future time, the stars will burn out and the universe will no longer support life.

In previous chapters (see 1 and 2 particularly), we have seen William Thomson, Rudolf Clausius, and W. J. M. Rankine as they struggled to articulate the first and second laws of thermodynamics during the early 1850s. Their efforts represent a distinctly Victorian contribution to science, and chime with the industrial concerns over thrift, waste, and efficiency characteristic of the Victorian era. Anxiety over the laws of thermodynamics appears in many of the writings of scientific and scientifically-inclined authors from the time. Recently, critics have observed thermodynamic traces in the works of a surprisingly diverse array of authors. Barri J. Gold, in her insightful monograph *ThermoPoetics: Energy in Victorian Literature and Science*, surveys the import of the first and second law of thermodynamics for such authors as Tennyson, Spencer, Bulwer-Lytton, Dickens, Wilde, and Stoker. Similarly, Jude Nixon, in his "'Eternity and the Vesture of Time': Carlyle, Thermodynamic Discourse, and Apocalyptic Anxieties," examines Carlyle's scientifically-informed philosophical anticipation of the laws of thermodynamics. No Victorian writer, however, with the exception of practicing scientists themselves, was so centrally concerned with thermodynamic science as was the priest of instress, the Jesuit poet Gerard Manley Hopkins. A bevy of critics, including James Leggio, Gillian Beer, Daniel Brown, Jude Nixon, Marie Banfield, and Hazel Hutchison, have demonstrated the integral reliance of his poetics on contemporary thermodynamic theory.

Most students of Victorian culture regard Darwinian naturalism as the central scientific discourse of the era. Yet many Victorians – particularly scientific Victorians – subordinate natural history to natural philosophy.[133] To quote no less a luminary than John Tyndall himself in his famous Belfast Address of 1874, "In our day grand generalizations have been reached. The theory of the origin of species is but one of them. Another, of still wider grasp and more radical significance, is the doctrine of the Conservation of Energy," articulated as the first law of thermodynamic science (Tyndall 45). Tyndall continues to explain the importance of this "doctrine": if all forms of energy express a single, underlying unity, then all science or all study of the natural world remarks the manifold permutations of this univocal force.[134] Essentially, all

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[133] See my discussion in Chapter 1 of the ways Victorian physicists sought to extend their empire to govern chemistry, sociology, biology, and evolution. Tyndall himself participates in this imperial effort, arguing that the principle of the Conservation of Energy "bring[s] vital as well as physical phenomena under the dominion of that law of causal connexion which, so far as the human understanding has yet pierced, asserts itself everywhere in nature" (45). Subsequently, Tyndall explains that the law of Conservation of Energy (i.e., the first law of thermodynamics) was "applied in the first instance to inorganic" matter by physicists, but has "rapidly embraced organic nature" (45).

I should note that Tyndall himself was a physicist and may have reflected an occupational bias in esteeming natural philosophy over natural history. Yet other Victorians, most notably Herbert Spencer, recreate the same prioritization. For Spencer, the principles of energy or force as described by natural philosophers condition all historical development, whether natural or social.

[134] In this paragraph, I use force and energy as synonyms in deference to Tyndall's usage. The relationship between these terms was contested, however, and marked the vitriolic machinations of the North British School and the X Club against each other. North British scientists Thomson, Tait, Stewart, Rankine, Maxwell, Hamilton, and others defined energy as the general term and force as a particular application of physical energy to change the motion of an object. The X Club, however, comprising Tyndall, Huxley, and Spencer among others, favored force as the

science becomes physics, the study of the transformation of force. Botanists study energy's permutations from solar light to chemical chlorophyll; biologists study the pathways by which the energy of chemical bonds is released in digestion and stored in the tissues of the body; psychologists study the fine impulses of energy within the nerves and brain responsible for sensation and thought; and even sociologists (Tyndall names Herbert Spencer) account for human relations according to the thermodynamic laws of energy.

If Tyndall in his 1874 speech explains the central importance of thermodynamics for Victorian science, William Thomson, in an 1862 article written for *MacMillan's Magazine*, explains the importance of thermodynamic science for Victorians in general. Thomson in his brief article creates a theology of thermodynamics that not only set physics in relation to religion, but that also expresses a cultural anxiety generated by thermodynamic discovery: entropy, specifically the death of the sun.[135] In his article "On the Age of the Sun's Heat," Thomson, later Lord Kelvin, estimates the point at which the sun will expire. Thomson calculates that the sun, upon first forming, held enough energy to light and heat the earth for 10-100 million years. He concludes ominously: "As for the future, we may say, with equal certainty, that inhabitants of the earth cannot continue to enjoy the light and heat essential to their life for many million years longer unless sources now unknown to us are prepared in the great storehouse of creation" (393).

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general term. An author's choice of energy versus force was perceived as a shibboleth marking sympathy with either the X Club or the North British School. That fact that these terms were territorial markers appears in the letters and writings of P. G. Tait, who on several instances lambasted authors for unwittingly using the "wrong" term.

[135] The word entropy describes the tendency of energy to disperse evenly throughout a closed system. In other words, entropy describes the tendency of energy to become "dissipated" (Thomson's term) and unavailable for use.

However, Thomson's introduction tempers his conclusion. In his introduction, Thomson reasons that since life began by God's "overruling creative power," it will be upheld by God's power as well. In Thomson's words,

> It is also impossible to conceive either the beginning or the continuance of life, without an overruling creative power; and, therefore, no conclusions of dynamical science regarding the future condition of the earth can be held to give dispiriting views as to the destiny of the race of intelligent beings by which it is at present inhabited. (356)

Such a claim, particularly in an article centrally concerned with the origin and duration of the sun's life-giving energy, positions God's "creative power" and the energies of the cosmos in close relation. While Thomson does not equate God's creative power with the other forms of energy in the world, he does posit a causal relationship between it and them. Given this introduction, Thomson's final words in his concluding sentence -- "unless sources now unknown to us are prepared in the great storehouse of creation" – accrue greater weight and certainty. No matter the age of the sun's heat, Thomson trusts in the "creative power" of God to sustain life, not in the energy stored in the sun.

Hopkins' sonnet to God's grandeur shows a similar anxiety about energy, and expresses a similar trust in God's creative power. While Thomson addresses the ravages of entropy, Hopkins makes sinful industrial society implicit with entropy in "dissipating" the natural energies of the world that God entrusted to humanity to husband.[136] Like entropy, industrial waste disperses energy for naught, producing death and illth instead of life and wealth. Additionally, entropic

[136] "Dissipation" is Thomson's term, but Hopkins' linkage of entropy with Satan and sin (see below) signals his concurrence. For a discussion of the moral implications of Thomson's terminology, see Crosbie Smith, *The Science of Energy,* pages 101-2 and 110-11.

production decreases the amount of energy available for future production. In the imagery of the sonnet, humans have trampled nature underfoot: After “Generations have trod, have trod, have trod” the earth with their hard-“shod” feet, the soil “is bare now” and incapable of producing more (5, 8). “Seared by trade,” and “bleared, smeared with toil,” the earth at the end of the octave appears exhausted and depleted (6).

In the sonnet, industrial waste or the denudation of the world functions as a type of entropy. But as a type, industrial excess also corresponds to sin. Immediately before the second quatrain’s catalog of industrial excess, the sonnet’s narrator questions “Why do men then now not reck his [God’s] rod?” (4). Given this introduction, the second quatrain’s account of industrial waste appears as an instance of dis-reckoning God’s rod, or rebelling against his rule. Accordingly in the logic of the poem, industrial mis-spending of energy is both entropy and sin. Entropy and sin are figuratively linked, then, but what form does this figure take? Does entropy merely represent sin, in the figure of a metaphor, or is entropy physically or causally related to sin, in such a way that a concrete relationship obtains? In short, is entropy a metaphor or a metonymy for sin?

In linking sin and entropy, Hopkins is not entirely original. Rather, he follows scientific language and the general Victorian virtues of thrift and economy. William Thomson, the prominent physicist and co-locutor of the laws of thermodynamics, applied the word “dissipation” to describe the workings of entropy. Like Hopkins, and like Victorians in general, Thomson felt a deep responsibility to apply God’s gift of energy appropriately. As Crosbie Smith writes,

> [Thomson’s] resolution [to articulate efficiency criteria for industrial machines] rested upon a fundamental conviction that ‘everything in the material world is

> progressive'. The directional flow of energy through space offered human beings the opportunity of directing, though not restoring, the mighty gifts of the Creator, the energies of nature. . . . Human beings had a duty to employ [industrial] engines for the benefit of mankind and in aid of its commercial and moral 'progress'. Failure properly to direct and harness those gifts of energy was therefore only a waste, and in that sense a sin of 'dissipation'. (Smith 101)

In one sense, dissipation describes the way energy disperses within a system. But as Smith observes, "dissipation" also carries the connotation of moral degeneracy, of prodigality and riotous living. Waste for Victorians, and for Christians in general, is a moral matter. Dissipated energies are symptomatic of moral dissipation. Particularly for the ecologically-conscious Hopkins, industrial pollution and spoilage would have been a direct violation of God's first command to human beings to "dress and keep" the Garden. Furthermore, in industry's collusion with entropy to "dissipate" the divine energies invested within nature, industrial mis-production appears all the more egregious.

In allying sin and entropy, Hopkins' poetry chimes with Victorian culture. The association appears even more explicitly in Hopkins' spiritual writings. Jude Nixon observes that Hopkins in his notes on the Great Sacrifice depicts "the Devil [as the] architect of entropy" ("Death Blots" 137). While Hopkins does not use the word "entropy" in these notes, Nixon is nevertheless correct. Much of Hopkins' notes are devoted to explaining Revelation 12, in which the "great red dragon" attempts to devour the child of the woman in the wilderness. Hopkins interprets the red dragon as Satan, the woman as Mary, the child as Jesus, and the wilderness as the world of matter. As Hopkins explains, Satan, knowing God's plan to incarnate the Son within matter, made plans to forestall the incarnation by eliminating the human race. In Revelation 12, the red dragon vomits a river of water from his mouth to sweep the woman away, but the earth preserves her by swallowing up the flood. As in the *Wreck of the Deutschland*, Hopkins typically interprets rivers as symbolizing passage of time, and he follows this pattern here in his meditation. Already in the present meditation on the Great Sacrifice, he has compared time to "the Sea of Galilee, which has the Jordan running though it and giving a current to the whole" (196).

Accordingly, Hopkins interprets the dragon vomiting the river from its mouth to "[mean] that Satan, who is the *cosmocrator*, the worldwielder, gave nature all an impulse of motion which should destroy human life" over time (198). Apparently, this impulse was death. But it was death in a much more virulent form than humanity currently experiences, for the world, in sympathy with humanity, swallowed up the river "to digest and distribute it throughout, making [the world] still habitable for man" (198). The material world engorged Satan's curse, dispersing the curse throughout its bulk in order to preserve humankind from taking the full brunt of Satan's rage. Presumably, had the world not done so, Satan's mordant curse would have worked death too rapidly within the human frame to allow reproduction and propagation of the species.

Thus the world drinks death from the serpent's mouth.[137] Accordingly, Hopkins considers the symbolic meaning of a coil or spiral-shape of a serpent. As Hopkins muses, "A coil or spiral shape is then a type of the Devil, who is called the old (or original) serpent, and this I suppose because of its 'swale' or subtle and imperceptible drawing in towards its head or centre, and it is a type of death, of motion lessening and at last ceasing" (*Sermons* 198).[138] Yet in considering the

[137] Hopkins switches between referring to Satan as a dragon and as a serpent. As Hopkins explains, "a dragon is a serpent with any addition you make" (199).

[138] Once more, Hopkins' penchant for concrete figures appears in this passage. Notice that the coil is a symbol and not merely a metaphor for death and Satan. When Satan appears in the form of a serpent, he *is* a coil, and moves by coiling and uncoiling his body. While it may be argued

coil as a figure of death, Hopkins does not restrict death to humans or sentient beings. Rather, Hopkins speaks of death as a principle of energy within nature, of "motion lessening and at last ceasing." In short, Hopkins speaks of death as entropy.

Hopkins' equation of death with entropy appears in his subsequent figure likening creation to a machine. In this, Hopkins overtly tailors his account of creation to the language of thermodynamics, energy, and entropy. In his *Reflections on the Motive Power of Fire* (1824), the French engineer Sadi Carnot described a hypothetically perfectly efficient machine as being completely reversible. In such a machine, no power would be lost to friction or heat conduction. Since the machine lost no power in its forward stroke, it would retain the same amount of power to work in reverse. Working backwards, then, the machine could accomplish the same amount of work as it did working forwards, without needing any additional fuel. William Thomson adapted Carnot's *Reflections* in his articulation of the second law of thermodynamics. Essentially, Carnot's machine defied entropy, and lost no energy as heat through friction or conduction. Carnot's machine was perfectly efficient – a true perpetual motion machine.

In the present passage, Hopkins likens creation as God originally intended it as a similarly perfect machine, capable of perpetual motion. Hopkins proceeds to explain that "God gave things a forward and perpetual motion; the Devil, that is / thrower of things off the track,

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that Satan is not truly a serpent, and that serpents are merely metaphors for Satan, such an argument sidesteps the manifest imagery of Genesis, Revelation, and Hopkins. Neither is a coil merely a metaphor for death. In its behavior of "subtle and imperceptible drawing in towards its head or center," a coil enacts the lessening motion of entropic death. A coil then is a metonymical symbol or a sign, not a metaphor, and instantiates death in physical and concrete terms.

Hopkins in this meditation also casts the earth and the material world in a figurative relationship. Hopkins explains "[Satan] was foiled, cast from heaven, and left master only of the material world, by a figure the earth" (198). The "figure" that Hopkins describes here is synecdoche. The earth is a part of the material world. Once more, Hopkins' figures and analogies are rarely mere metaphors, but usually partake of a substantial or concrete identification. In such a passionate devotee of the Real Presence, such an estimation of figures makes sense.

upsetter, mischief maker, clashing one with another brought in the law of decay and consumption in inanimate nature" (*Sermons* 199). As God originally ordained creation, it was a perfectly efficient machine, entirely free of friction and capable of running perpetually without loss of available energy. Yet Satan damages God's machine, warping and bending its parts to grind against each other and to produce friction. Satan "clash[es] one [part] with another," and the resulting loss of energy as the machine's parts grind upon each other makes the machine imperfectly efficient.[139] Gradually, the machine's motive force will be leached away through friction as unusable heat, and over time it will slow and stop. Thus, if the word is a machine, Satan is a devilish mechanic bent on stalling the device.[140]

The entropic friction of death that Satan introduces to the world effects all created matter, "[bringing] in the law of decay and consumption in inanimate nature, death in the vegetable and animal world, moral death and original sin in the world of man" (*Sermons* 199). The total wages of sin may be summed in one word: entropy. Entropy causes the inanimate world to waste and decay, brings death to plants and animals, and corrupts the nature of human beings.

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[139] The trope of grinding, groaning machinery clashing together recurs in Hopkins' Dublin sonnets. Invariably, the machine's frictional inefficiency forecasts its demise. In "Patience, Hard Thing," the poet portrays the human heart as a friction-fraught machine, observing that "we hear our hearts grate on themselves: it kills to bruise them dearer." That the heart is a "failing" machine appears more forthrightly in "To His Watch" when the speaker likens his beating heart to his ticking watch, and wonders "shall I earlier or you fail at our force"? Another grinding machine appears in "Spelt from Sibyl's Leaves," where the world is a torture machine -- a "rack" -- upon which "thoughts against thoughts in groans grind."

[140] In this figure of world to machine, Hopkins again avoids mere metaphor. If the world genuinely does operate according to mechanical principles as Victorian science claimed it did, then the world truly is a machine. When the Enlightenment authors first compared creation to a clock or watch, they may have been invoking metaphor. But Hopkins and his Victorian contemporaries truly regarded "all nature as mechanical" (*Journals* 252). Nature was not *like* a machine; it *was* a machine.

In effect, then, Hopkins compares a large machine (the world) to a small machine (an industrial engine). The comparison hinges on scale, not likeness in difference. Once more, the comparison is metonymy instead of metaphor.

If entropy and sin are figuratively related, the figurative relationship is not merely metaphorical. For Hopkins, entropy is the universal instantiation of sin's final cause, and signifies sin as an effect signifies its cause. Sin causes entropy, and thus entropy stands in for sin by metonymy of effect for cause. Moreover, entropy is the sign or symbol of sin, the physical manifestation of sin in the material world. Sin and entropy are not merely like each other in certain respects, then, but are wholly identified with each other. By Raymond Wilson's definition, entropy is Hopkins' "metonymical symbol" for sin ("Ricoeur's 'Allegory'" 297-9). Once more, Hopkins eschews metaphor for a more concrete and physical analogy.

Repeatedly in Hopkins' writings, energy sublimes from the physical to the metaphysical, passing from the one state to the other and reconciling both as aspects of a single integrated universe. Accordingly, the first quatrain of "God's Grandeur" accounts for God's outstress as a form of natural energy much like electricity, light, or heat. Importantly the likeness between grandeur and other forms of energy is not metaphorical. Rather, the analogy depends on metonymy, and God's outstressed grandeur relates to electricity, heat, and light as one form of energy relates to another. Similarly, in Hopkins' spiritual journals, entropy is the metonymical symbol of sin, including the sinful waste of natural energy by misguided industrial production. Much as natural energy instantiates God's creative outstress, so entropy instantiates sin.

While the sestet of Hopkins' sonnet answers and overturns the octave in several ways, it also follows from the octave in representing energy's permeation of the physical and the metaphysical. In order for the healing power of the Holy Spirit's "warm breast" and "bright wings" to reverse the onslaught of industrial mis-spending (and by extension, the world's loss of energy to entropy), this power must be energetic. In other words, the Holy Spirit's outstress must be communicable with natural energy, or with electricity, light, heat, magnetism, and work. The regeneration of the world that the poem describes is physical and spiritual at once, and depends upon the interposition of physical energy to counteract entropy and entropic industy.[141]

As we have seen, William Thomson trusted life's preservation to the "overruling creative power" of God (356). Hopkins, in the sestet of his sonnet to God's grandeur, expresses a similar faith that despite industrial waste and even more broadly, despite entropy itself, God's creation and the vital energy within his creation will persist:

> And, for all this, nature is never spent;
> There lives the dearest freshness deep down things;
> And though the last lights off the black West went
> Oh, morning, at the brown brink eastwards, springs –
> Because the Holy Ghost over the bent
> World broods with warm breast and with ah! bright wings. (9-14)

To closely paraphrase the sestet, nature is never spent because there "lives" a "dearest freshness" deep down in things. Far from a commonplace or castaway term, the verb "lives," together with the expression "deep down," suggests that "dearest freshness" identifies a vital energy or force – instress. Furthermore, if the instress resident within and intrinsic to objects descends from the outstress by which God created the world of objects, then the difference between outstress and instress is a matter of perspective. The power that God outstressed from himself into the world is the same power that he instressed into his creatures at their creation and which he continues to instress in maintaining their being. In the words of the sestet, the dearest freshness that lives deep down in a thing is simultaneously the thing's own instress and God's

[141] As a caveat, please review my discussion of "outstress" on pages 45-46. I do not mean that Hopkins viewed the substance of God himself as physical or natural, or that Hopkins viewed the eternal power and deity as conformable to nature. Instead, I mean that the power that God's outstressed into creation was a bona fide form of energy.

outstress. God's outstress is the creature's instress, much as Christ is his creatures in Hopkins' "Kingfisher" sonnet: "Christ plays in ten thousand places,/ lovely in limbs, lovely in eyes not his/ to the Father through the features of men's faces" ("Kingfishers" 12-4). If each individuated being is an expression of Universal Being, then each creature in its innermost identity expresses an aspect of God's nature.[142]

Similarly, the vital energy or instress of each object stems from the vital energy that God outstresses to the world. Thus, "nature is never spent," "there lives the dearest freshness deep down things," and "morning over the brown brink eastward springs" because "the Holy Ghost over the bent world broods with warm breast and with ah! bright wings." Much as God's grandeur figures in the first quatrain of the octave in physically energetic terms as charging and flaming and shining, so the Holy Ghost figures in terms of heat (warm breast) and light (bright wings). The "dearest freshness" deep down in things is supplied by the creative energy from the Holy Ghost.

Yet just as ontological "freshness" depends on the Holy Spirit's warm breast and bright wings, so do the "never spent" energies of nature. The Holy Spirits' outstress is not merely an ontological or metaphysical force. Contrarily, if the octave threatens the extinction of physical

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[142] Much the same conclusion may be drawn from Hopkins' expression "dearest freshness." Typically in Hopkins' poetry, the one that he calls "Dear" or "my dear" is God or, more specifically, Jesus. "The Windhover," for instance, is addressed "to Christ our Lord." In the second tercet of the sestet, Hopkins apostrophizes Jesus as "ah my dear." A similar apostrophe appears in "In the Valley of Elwy" when Hopkins implores "God, lover of souls, swaying considerate scales,/ Complete thy creature dear O where it fails,/ Being mighty a master, being a father and fond." While "dear" evidently modifies "creature," it can also be considered an apostrophe addressing God. In other instances, however, "dear" unambiguously modifies creatures. In "Binsey Poplars, the speaker mourns "my aspens dear" that have been "all felled, felled, … all felled." Similarly, the intercessory speaker of "Henry Purcell" prays for the spirit of Henry Purcell, "so dear to me." Yet given that Hopkins views the inscapes of creation as "word, expression, news of God," the dear qualities of creatures express the nature of Hopkins' dear Lord (*Sermons* 129).

energy due to entropy and wasteful industry, then the energy resupplied by the Holy Ghost must also be physical. In the logic of "God's Grandeur," the Holy Spirit replenishes not merely a spiritually drained world, but an energetically drained world, a world depleted by entropy and industrial misspending. In order for the Holy Spirit's outstress to be restorative, the warmth of his breast and the brightness of his wings must be physically communicable in terms of natural energy.

4.5 Summary

In the beginning of this chapter, I observed a distinction commonly made in Hopkins' scholarship among spiritual, psychological, and physical stresses. This distinction stems from Hopkins' poetry, namely his frequent metaphors linking spiritual and psychological energy to physical stress. If the relationship between metaphysical and physical stresses is "merely" metaphorical, then critics legitimately distinguish the two categories.

Contrarily, I argue that Hopkins' metaphors are often more than metaphorical. In contrast to the normal operation of metaphor that Ricoeur describes, Hopkins' metaphors often lack the absurd negation of tenor and vehicle. In a typical metaphor, the absurd negation between tenor and vehicle forces readers to reinterpret figuratively the metaphor's literal claim. To effect this figurative reinterpretation, readers empty the vehicle of its concrete objectivity and transmute it to a semantic quality that may be applied to the tenor. Hopkins' metaphors, however, lack this absurd negation, and tenor and vehicle correspond readily in a literal and concrete sense. To put it baldly, Hopkins' metaphors are often more (or less) than metaphorical, and often make literal claims. While Hopkins' metaphors are conventional in form, they are unconventional in function. If Hopkins' vehicles pose no absurdity and retain their concrete objectivity, then by Ricoeur's theory they provide no impetus to abstract the metaphor's literal claim.

The strangeness of Hopkins' metaphors stems from the unusual ontology compressed within in his poetic mythos of the Great Sacrifice. The ontological correspondence of created things in Christ authorizes metaphoric comparison. Accordingly, in "As Kingfishers Catch Fire," the semantic relations posited by metaphor point to a deeper consanguinity stemming from creatures' participation within Christ's universal nature.

But Hopkins' metaphors apply to energy as well as to matter. In "God's Grandeur," Hopkins compares divine outstress with natural forms of energy. Once more, the Great Sacrifice authorizes metaphorical comparison. If physical energy originates from the outstress of Christ's progressive incarnation in the Great Sacrifice, then not only does all physical energy correspond, but divine or metaphysical outstress corresponds with physical energy. Energy is not confined to relations between material objects, but rather scales from the physical to the metaphysical. Much as Christ's universal being finds expression within the specially distinct forms of creatures, so his outstress finds expression in the physical forms of energy – light, heat, magnetism, electricity, and work. In all, Hopkins' is an integrated cosmos: not only is the metaphysical immanent within the physical, but the same order shapes the seen and unseen world alike.

5 HELL IS ENERGY: SCAPES, INSTRESS, AND HOPKINS' ENERGETIC MODEL OF CONSCIOUSNESS

The present chapter extends from the previous, and explores the role of energy in Hopkins' literary representations of subjectivity. Particularly, this chapter will compare Hopkins' term instress to contemporary brain and aether science. It will ultimately argue that instress should be understood as a form of energy mediating body, matter, and substance generally.

"Body," "matter," and "substance" are complex terms, and the extent of their overlap varies depending on the author one reads. Hopkins, as a Catholic and a special devotee of Duns

Scotus, would have been familiar with the Scholastic treatment of these terms. In Scholastic philosophy, substance acts as the most general term and applies to all that exists, whether physically (as matter) or metaphysically (as mind, soul, and perhaps even God). Matter forms a subset of substance, then, and characterizes all that exists physically or materially, as opposed to all that exists metaphysically or immaterially. Body is the most specific term, and may be defined as an arrangement of material substance. In plant and animal bodies, the arrangement is orchestrated to promote life throughout the body's parts. However, nonliving objects may also be referred to as "bodies," provided they exhibit some principle of coherence, combination, or arrangement. Effectively, body may be taken as a particular instance of matter.

The trouble with "body," "matter," and "substance" begins when entities typically treated as immaterial are considered materially, whether as matter per se or as somehow analogous to matter in composition or function. This was the trouble characteristic of what Alan Richardson calls the "Romantic brain science" of the late eighteenth century through the nineteenth century: the immaterial mind was made conformable to the material brain and body. This was also the trouble characteristic of aether theories of the same period. In several regards, in its imponderability, incompressibility, fluidity, rarity, and imperceptibility, aether approached immaterial substance. Yet in other regards, particularly in its capacity to transmit energy, aether was the substrate of all material processes. Accordingly, the eighteenth and nineteenth century sciences of brain and aether illustrate the quandary of distinguishing between physical and metaphysical existence.

William Cohen sees this troubling trend in Victorian literature generally as ghosts, souls, and psychology began to be discussed in increasingly material terms. While Cohen recognizes that many Victorian writers cherished "spiritual aspirations [. . .] such as a Christian afterlife and an immortal soul," he argues that these authors consider the soul as "interior to the individual," closed up within and in some mysterious way substantially consonant with the fleshly body (131, xi). While Hopkins was not a materialist, he nevertheless was sensitive to this trend, and he responded to its challenge (see his "The Probable Future of Metaphysics" for one). In this chapter, I argue that while Hopkins takes metaphysical substance at face value, he nevertheless situates the metaphysical realm in the same universe as the physical. In Hopkins' writings, the laws of energy govern the physical and metaphysical worlds alike, and energy spans substance.[143]

Specifically, this chapter will compare Hopkins' psychology to Victorian brain science, and his vision of hell to scientific models of the aether. Both comparisons show energy mediating physical matter and metaphysical substance. Pertaining to Hopkins' theory of mind, Hopkins insists that thought begins not in the physical brain but in the spirit, and thus "the activities of the spirit are conveyed in those of the body" (287). In accord with nineteenth century brain science, however, Hopkins admits that the embodied brain plays its necessary part, and that the "images" or "scapes" within the mind are "in fact physical and a refined energy accenting the nerves" (*Oxford Essays* 307). Likewise, in his meditation on hell, Hopkins acknowledges that the pain the souls in hell feel must be "imaginat[ive]," since the souls are disembodied and have no bodies with which to feel (*Sermons* 136). Nevertheless, Hopkins describes hell as a torture machine that sets souls on fire through friction by setting them "texturally at stress" within two opposed fields of energy (136). In its unabashedly mechanical functioning, albeit a mechanical functioning the preserves space for metaphysical existence, the

[143] However, it should be remembered from chapter 4 that while Hopkins' metaphysical world includes angels and the souls of human beings, it does not include God. As uncreated, God's Being rests outside and beyond creation.

hell Hopkins depicts resembles several nineteenth century scientific models of aether. In fine, this chapter compares' Hopkins conceptions of mind and soul to contemporary scientific theories of psychology and aether, arguing that in either case, energy mediates material and spiritual substance.

5.1 Review of Scholarship

A handful of critics have observed the physically energetic nature of Hopkins' instress. Gillian Beer surveys Hopkins' knowledge of physical science, and reads "That Nature is a Heraclitean Fire and of the Comfort of the Resurrection" and "The Blessed Virgin Compared to the Air We Breathe" as analogues of contemporary developments in thermodynamics and optics. Similarly, D.C. Haggo interprets the resurrection in "Heraclitean Fire" as a chemical reaction which changes the speaker's carbon (his "matchwood") to "immortal diamond." John Gordon, explicating "The Windhover" in terms of Victorian meteorology and electricity, describes the synergy between falcon and speaker in terms of the charge between cloud and sky at the moment of thunderstrike. Likewise, Marie Banfield interprets "Spelt from Sybil's Leaves" as a vision of thermodynamic apocalypse, observing a simultaneous decomposition of energy and order as the selves in the poem steep and pash together. And most recently, Hazel Hutchison scans the metrical stresses of Hopkins' verse for correspondence with theories of stress in Victorian physics, showing both the poetic and the scientific enterprise as engaged in expressing "the problem of whether sequences and laws within language as in nature are objectively apprehended or imposed on the riot of sensory experience available to the individual mind" (231).

While the aforementioned critics read Hopkins' poems against developments in nineteenth century energy science, three critics – James Leggio, Daniel Brown, and Jude V.

Nixon -- stand out for defining the term instress as a form or field of energy. James Leggio, writing in 1977, was the first to my knowledge to observe that "a number of [Hopkins'] undergraduate poems deal with entropic conditions," or translate the newly-enunciated second law of thermodynamics into poetic terms (60). As Leggio explains, the second law describes the tendency of energy in any closed system to transform into heat and disperse throughout that system. Since the universe is a closed system, albeit on a grand scale, the second law describes the way heat radiates from hot regions of the universe – stars, primarily, but also the planets close to stars or with atmospheres sufficiently dense to hold heat – into space. As interpreted by Victorian physicists, the second law of thermodynamics points to a final and universal consummation when the heat of the cosmos will be uniformly distributed throughout all matter. The warm regions of the world will equalize with the cold, and the resulting temperature will be too low to sustain life. Not only this, but since energy flows from high to low concentrations, a universally uniform concentration of heat will effectively forbid all movement, transfer, and process, and the universe will "[decelerate] [. . .] to a dead stop" (Leggio 57).

Leggio accordingly interprets several of Hopkins' undergraduate poems – "A fragment of anything you like," "I am like a slip of comet," and "Summa" – in terms of the entropic apocalypse predicted by Victorian physicists.[144] Yet in Hopkins' later poems, Leggio sees an opposing principle at work, one that maintains God's creation by replenishing the energy lost to the cold wastes. Leggio identifies this principle as instress, claiming that far from being a poetic fiction or metaphorical cipher, instress in Hopkins' poems describes a real and literal force, an

[144] I should note that I have suppressed here the understated but influential quandary regarding Hopkins' knowledge of physical science as an Oxford undergraduate. For my discussion of this quandary, please see chapter 3.

interposition of energy direct from God. The chief sources of instress, Leggio claims, are Christ's historical Incarnation and his ongoing incarnation as the Real Presence in the host:

> The language with which Hopkins describes the Incarnation and the Blessed Sacrament suggests that he senses in them a theological counter to the predictions of the new astrophysics [or thermodynamics]; the transformation of bread and wine into body and blood provided a model for change that served as an alternative to the physicist's model of thermodynamic relations. (63)

While Leggio here treats the instress of incarnation as analogous to ("as a model for") actual energy, he later phrases his argument much more directly: "The Incarnation brings energy from outside into the closed entropic system we call the universe" (64). Instress then is divine power translated to physical energy. Furthermore, in preserving God's creation from heat death, instress is a physical analog of spiritual grace. As Leggio writes, "The action of grace compensates for a spiritual condition resembling the diffusion of heat energy. God's grace is analogous to the fire: without it the soul, and the universe, cool. Grace puts new energy into the system and keeps it going" (62).

Daniel Brown also observes the likeness of grace to instress, observing that "grace is [. . .] equivalent to 'divine stress'" (261). As discussed in chapter 3, stress for Brown is an ontological force by which objects come to be and maintain their hold on being.[145] Given that all particular beings originate from Jesus' universal Being, or – phrased alternately – that

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[145] There are actually two opposed types of stress, flushing and foredrawing. As Brown describes, objects consist as particular iterations of universal Being. Universal Being "flushes" all things, but each object "foredraws" to form its discrete self. If flushing and foredrawing are opposed stresses, instress describes the unique balance of stress (flushing vs. foredrawing) that results in the particular object. Accordingly, stress in its total sense is a field of ontological force, and flushing and foredrawing are opposed types of stress within this larger field. Instress, furthermore, is a specific configuration of stresses – a specific balance of flushing and foredrawing -- within the field of stress.

"ontological force" simply renames God's power outstressed at creation, the "divine stress" that Brown describes is a field of spiritual force suffusing all creation and maintaining the being of each created thing. If stress is a field of divine force, then an instress is a particular point of energy within this field: "Instress can be represented [. . .] as a discrete point, a knot or vortex, of energy in the field of being, and particular stresses, such as those of grace or the epistemological 'stem of stress', as lines of force in this field" (238).

In likening Hopkins' "divine stress" to a field of spiritual force, Brown finds cultural analogues in the field theory of Michael Faraday and the aether theory of James Clerk Maxwell. As Brown writes, "Hopkins' [. . .] physical principle of stress [. . .] strongly suggests the [. . .] field [theory] that Faraday pioneered," which was subsequently adapted to Maxwell's "mechanical model for an ether" (238). Brown argues that in Hopkins' model of reality, instress and nature stand in relation to Faraday's field and Maxwell's aether: much as Maxwell's aether is the medium through which Faraday's field acts, so nature is the medium of through which instress acts. Particularly, nature bridges the distance between God and human beings, and mediates or carries God's outstress – grace -- from Him to his creatures. Thus Brown observes that in "Duns Scotus' Oxford," the "'Towery city and branchy between towers' has its intervening spaces filled with energetic commotion" (241). In "Spring," the lightning-stroke of the thrush's song travels to the listener's ear through the "echoing timber" of the wood (242-3). Likewise, in both the *Wreck of the Deutschland* and "The Virgin Mary Compared to the Air We Breathe," God's sunlight travels through the liquid blue of the May-month's sky (243-4). As Brown explains, given that the various energies – the commotion, the lightning-stroke, the light of the sun – in these scenes are instances of instress or "divine stress," then nature is the medium in which the field of divine grace acts to draw percipient observers to their Creator.

An aspect of Brown's analysis bears further comment. While Brown likens Hopkins' religio-poetic philosophy of instress in nature to Faraday's and Maxwell's physical theories of energy, the comparison remains elusively metaphorical. Brown repeatedly relates the philosophies of the poet and the physicists in analogical terms: "Hopkins' identification [. . .] of stress forms an ontology *that strongly suggests* the mechanistic concept of the field"; "Instress *can be represented* according to the ontology of Faraday's theory"; "Nature is often depicted by Hopkins *in a suggestive analogy* to the dynamic principle of the physical field"; (238, 238, 241 my emphasis). So prefaced, Brown's analysis treats the overlap between Hopkins' instress/nature and the Victorian theories of energy/aether as metaphorical, when Hopkins' consistently energetic descriptions of instress seem to call for a more direct and literal equation. In simple terms, Brown treats physical energy as an analogy for spiritual instress, as if the physical and the spiritual worlds are ultimately separate and distinct. Following Leggio and Nixon (see below), I will argue that for Hopkins, the spiritual and the physical belong to a single, integrated universe. Much as Hopkins' scientific contemporaries were rapidly unifying the various energies in nature as various forms of a single, pervasive force, so Hopkins posits spiritual instress as yet another manifestation of nature's power.

Jude Nixon seconds James Leggio and Daniel Brown. Like Brown, Nixon discusses stress as a field of force. While Brown's analysis remains ambivalent, however, whether instress is physical energy or merely analogous to it, Nixon forthrightly identifies Hopkins' instress with the energies of nature, specifically with electromagnetic energy. As Nixon explains, "Hopkins assumes that electromagnetic energy, seminal fluid or 'instress,' flows from God" (144). And like Leggio, Nixon asserts that through instress God infuses the world with new energy to compensate for that lost to entropy:

> Hopkins' [cosmic] economy relies on ample supplies of energy to counter entropic degradation [. . . .] To stave off entropy and to preserve caloric equilibrium, Hopkins employs Joule's Great Architect [God] who maintains the world's energy supplies – 'morning, at the brown brink eastward, springs--- / Because the Holy Ghost over the bent / World broods with warm breast and with ah! bright wings (146).

Thus the energy of the natural world ultimately stems from God, continually radiating out from him as electromagnetic instress to recharge the world from entropic dissipation.

This chapter takes its cue from Leggio, Brown, and Nixon, and will be motivated by two objectives. First, it will consider Hopkins' psychology, drawing from nineteenth century "brain science" to show that for scientifically-minded Victorians, the energies of the embodied mind and the immaterial spirit were closely akin to the other energies in nature.[146] Second, extending from Brown, this chapter will set Hopkins' energetic conception of hell against contemporary Victorian models of the electromagnetic aether.

5.2 A Meditation on Hell: Hopkins' Mechanical Model of Spiritual Instress

"I wake and feel," one of the most "terrible" of Hopkins' sonnets of desolation, includes this bleak autobiographical portrait:

> I am gall; I am heartburn. God's most deep decree
>
> Bitter would have me taste: my taste was me;
>
> Bones built in me, flesh filled, blood brimmed the curse.

[146] I do not mean to argue that Hopkins was a monist. He was without question a dualist. Yet in Hopkins' dualism, energy in its various manifestations partakes sufficiently of immateriality and materiality to mediate between the two states of being. Particularly, the "spiritual energy of instress" (alternately known as the "energy or instress with which the soul animates and otherwise acts in the body") is an exceedingly refined form of energy that acts upon the spirit or mind (*Sermons* 137).

Selfyeast of spirit a dull dough sours. I see
The lost are like this, and their scourge to be
As I am mine, their sweating selves; but worse. (9-14)

What makes the hellish curse of the sonnet so damning is its source. Although the curse may be enforced by “God’s decree,” it arises internally and ultimately becomes synonymous with the speaker’s selfbeing. God decrees that the speaker will taste bitterness by tasting bitter himself. Ultimately, the bitterness that the speaker tastes is his own being or “selftaste.”[147] The speaker’s very bones “build” his curse, his “flesh fill[s]” the bitter tankard of self, and his “blood brim[s]” the tankard to the full. Like the “lost” souls in hell, the speaker’s punishment – his “scourge” – is “to be [. . .] [his] sweating [self].” Much as with Milton’s Satan, the worst hell of hells is to be oneself: “Me miserable! [. . .]/ Which way I fly is Hell; myself am Hell; And in the lowest deep a lower deep/ Still threatn’ing to devour me opens wide” (*PL* 4.73-9).

The sonnet (1885-6) condenses Hopkins’ prior prose commentary (1881) on Ignatius’ “A Meditation on Hell.” As in the sonnet, the “lost” in the prose commentary are punished to be “their sweating selves.” Given the autobiographical character of the sonnet, the commentary possesses intrinsic interest for readers of Hopkins’ poetry. The commentary does not merely express Hopkins the priest’s conception of hell. Rather, the commentary expresses Hopkins the poet’s construction of self, and reflects his self-loathing during periods of despair. Not

[147] In this poem, Hopkins compares self-knowledge to eating. By his own account, the speaker’s self-knowledge is like tasting rancid “dough” that causes “heartburn” (12, 9). But in his spiritual writings, and at a happier moment, Hopkins compares self-knowledge to drinking the “tankard [. . .] of my own being.” At one point, Hopkins exults, “When I consider my selfbeing, my consciousness and feeling of myself, that taste of myself, of *I* and *me* above and in all things [. . . .] Nothing else in nature comes near this unspeakable stress of pitch, distinctiveness, and selving, this selfbeing of my own. [. . .] There is no resemblance: searching nature I taste *self* but at one tankard, that of my own being.” (*Sermons* 123). Part of the tragedy of the terrible sonnet is that the selfbeing that Hopkins celebrates in his other writings has turned into a bitter curse.

surprisingly given the close connections between sonnet and commentary, at issue in the commentary is the psychological ontology of the subject. Specifically, Hopkins' commentary inquires as to the material basis of memory and consciousness. Moreover, germane to the interests of this dissertation, the commentary sets memory and consciousness in the language of stress, or treats them as products of energy.

The commentary takes the shape of an essay, with a thesis that, while initially mystifying, gradually becomes intelligible as its subsidiary claims are elucidated. The thesis of the commentary is that "our action leaves in our minds scapes or species, the extreme 'intention' or instressing of which would be painful and the pain would be that of fire, supposing fire to be the condition of a body (and by analogy of any substance) *texturally at stress*" (*Sermons* 136, emphasis original to text).[148] Given that this thesis describes "the present condition of the lost" in hell prior to the resurrection of the damned (ie, a disembodied state that nevertheless feels pain), Hopkins writes that "it is by [. . .] the imagination that the lost suffer" (136).[149] From this,

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[148] A full definition of "scape" is made difficult by Hopkins' habitual practice of structuring words as matrices or concentric hierarchies of meaning (à la the previous chapters' discussion of stress) instead of as discrete terms. In the present instance, a scape is an organization of substance and energy to lend permanence to a past act. However, in a related usage of the word, a scape is a substantial organization of matter and energy that instantiates the nature of a created object. The two definitions are related, and, if space permits, I will entertain their associations below.

[149] Traditional Christian eschatology teaches that the damned, before their judgment, are imprisoned in hell in a disembodied state. Though disembodied, they nevertheless feel pain. At the judgment of the damned, the lost souls will be resurrected and reunited with their bodies. After judgment, the lost (now body and soul) will be sent not back to hell but to the lake of fire. Hell then is a temporal place of punishment for disembodied souls prior to judgment. The lake of fire, contrarily, is an eternal place of punishment for the whole being (body and soul) after judgment. The difficulty that Hopkins attempts to solve here is how the disembodied soul in hell can feel pain. He surmounts this difficulty by positing the soul as being composed of immaterial substance that is nevertheless capable of material relations – "tension," "texture," "stress," "extension," "energy," exertion, and pain (*Sermons* 136-7). Though the soul's substance is not bodily or grossly corporeal, it is substance still. For Hopkins, the energies and relations that obtain for bodily substance obtain for spiritual substance as well.

a number of questions occur: One, what is the nature of the substance of the soul, and how can it be set "texturally at stress" and burn? Two, how are the soul's scapes "instressed," and which energies or forces are involved in this instressing? Three, how does an instressed scape result in fire, and what is the nature of this "imaginative" fire? Each of these questions is compressed within the thesis and is critical to its meaning, yet is explained only after the thesis has been initially broached. Structurally, the commentary first posits a seemingly indefensible claim – that the soul and its imaginative pains are somehow susceptible to physical relations -- and then explains component parts of this claim to warrant the claim itself.

The first component claim addresses the nature or "substance" of the disembodied soul in hell. According to Hopkins' description, "our [past] action leaves in our minds scapes and species…" (136). It should be remembered here that Hopkins describes the disembodied soul in hell, not the currently embodied soul on earth. From this, the disembodied soul in hell has a mind (or perhaps is a mind), and the soul's mind contains "scapes" of its past embodied life on earth. Moreover, when these scapes are "instressed," they produce pain within the disembodied soul, and this pain is "that of fire, supposing fire to be the condition of a body (and by analogy of any substance) *texturally at stress"* (136).

Through parenthesis, Hopkins avoids referring to the soul as "a body." If the parenthesis were removed, then the only interpretation possible would be that the soul consists as a body of matter, albeit matter exceedingly refined. The parenthesis makes possible another interpretation, however – that not only is fire is the condition of any bodily substance texturally at stress, but that it is also, by analogy, the condition of "any substance" (including immaterial substances) texturally at stress. But Hopkins' parenthetical analogy prompts one further question: How can an immaterial substance have texture? How can an immaterial substance experience stress?

The present passage emphasizes, once more, the importance of Hopkins' analogy. While Hopkins casts body and soul in an analogical relationship, his language must be scanned in light of the previous chapter's discussion of Hopkins' metaphorical tenor and vehicle. Hopkins' exact words are "supposing fire to be the condition of a body (and by analogy of any substance) texturally at stress." In so saying, Hopkins sets up a synecdotal relationship between "body" (whether animate or inanimate) and "substance": body is a kind or subset of substance. Given that the larger passage concerns the disembodied soul, the specific "substance" that Hopkins apparently has in mind is the soul. Thus, "fire [is] the condition of a body [. . .] texturally at stress," and by analogy, "fire [is also] the condition of a [soul] texturally at stress." It should be noted here that "body" and "any substance" are not opposing terms. Rather, bodies of matter -- animate and inanimate alike -- represent one kind of substance, and souls and spirits represent another kind of substance. Hopkins' analogy between body and soul is not metaphorical in comparing two dissimilar things, but is rather metonymical, in the way discussed in the previous chapter, in comparing two parts within a larger whole. Body and soul are substance then, and the analogy shows the correspondence of one part (body) within another part (soul) within a whole (substance). In short, both body and soul partake of the larger category of substance, and Hopkins' metonymical analogy hinges upon likening the energetic relations characteristic of body to the energetic relations characteristic of substance generally, including those of the soul. Thus, the soul is set "texturally at stress" in a manner conformable to the way a physical body is set texturally at stress.[150] Instead of difference, Hopkins' analogy emphasizes correspondence, or the likeness of two things within a group.

[150] Admittedly, I have not yet answered how a soul may be set at stress, or how a soul may have texture. I will attempt to do so below.

Pertaining to the second question -- how are the soul's "scapes" instressed? – I will delay definition of "scape" until later in this chapter, except to say that scapes are the remnants of deeds (particularly sins) committed in the body while on earth.[151] This appears in Hopkins' later equation of "scape" with the soul's "act of its own, which blotted out God and so put blackness in the place of light" (138). Yet how are scapes instressed? Hopkins subsequently explains that the "energy or instress with which the soul animates and otherwise acts in the body is by death thrown back upon the soul itself" (137). It should be remembered, however, that Hopkins speaks here of the damned. That the soul-stress of the righteous is not reverted in death appears in his identification of the efficient and material causes of this reversion:

> How then is the soul so set at stress? As I suppose by some main stress from without, and that this is expressed by 'ingentes illos ignes' St. Ignatius speaks of, as the current of air in the blowpipe casts or addresses a jet of flame this way or that. The seven gifts the Holy Spirit are spoken of as seven spirits, seven jets or currents of breath; so it may be of 'the breath of the Lord that kindled Tophet of old', the stress of God's anger which first 'prepared' or called into being fire against the Devil and his angels (137)

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[151] I intentionally avoid using the word "memory" to emphasize the substantial composition of scapes. As I discuss below, a scape is a physical arrangement of the brain's matter that codes for past deeds and sensations. A scape is not an insubstantial idea, but is an arrangement of energy and matter that perpetuates an act within the physical brain. See my discussion of Hopkins' associationist psychology, below.

Curiously, however, these scapes persist in the disembodied soul even after death. Apparently the material brain-scapes are translated to the soul's substance where they exist immaterially (but not insubstantially – see footnote 7). Again in Hopkins' writings, the physical and the metaphysical belong to an integrated universe. Although the soul's scapes are not physical or material, they are substantial nevertheless. The laws of energy apply to substance generally, whether material or metaphysical.

Accordingly, the stress with which the soul animates the body in life is, at death, rebuffed or turned against itself by a countermanding stress "from without," from God. The stress of God's wrath reflects the soul's stress back onto itself, where it bores into and "instresses" the scapes of the damned soul's past. In this description, Hopkins treats soul-stress in physically energetic terms, effectively spanning the gap between the metaphysical and the material, or even the mechanical. Thus, Hopkins identifies the energy of the soul's instress, as well as the energy of the wrath of God, with the mundane relations of force and energy commonly on display on earth. Once more, the quality of Hopkins' analogy should be remembered. In setting the spiritual in the language of the material and even the mechanical, Hopkins is not comparing two dissimilar things. Rather, he is comparing two things that partake of the same larger category – namely, that of energy in the universal realm of substance.

The identity of spiritual with physical stress appears in several facets of Hopkins' commentary. Initially, the fact that Hopkins refers to the instress of the soul as "energy" likens it to the other forms of energy at play in nature. Moreover, the fact that the soul's "energy or instress" "animates [. . .] the body" implies that energy is capable of transposition from the realm of spiritual substance to the realm of material substance. In effect, energy is not relegated to gross matter, nor does the spiritual world operate by a qualitatively different form of energy than the material world. Instead, energy operates in the seen and unseen worlds alike, or, better said, the seen and the unseen are territories within the same world, the physical universe.

In depicting the reversion of the damned soul's stress, Hopkins treats the conflict between the soul's energy and God's wrath as an instance of mechanical reflection. At one point in his nature journals, Hopkins describes waves breaking upon and rebounding from the seawall of the Kennaway Tunnel:

> The seawall is picturesque and handsome from below – it is built of white and red and blue blocks and with a brim or lip or cornice or coping curved round to beetle over and throw back the spray without letting it break on the walk above: this shape and colour give it an Egyptian look. --- The laps of running foam striking the sea-wall double on themselves and return in nearly the same order and shape in which they came. This is mechanical reflection and is the same as optical: indeed all nature is mechanical, but then it is not seen that mechanics contain that which is beyond mechanics. (*Journal* 252)

Hopkins often describes God as a seawall. Perhaps the most memorable instances of this comparison may be found in the *Wreck of the Deutschland*:

> I admire thee, master of the tides,
> Of the Yore-flood, of the year's fall;
> The recurb and the recovery of the gulf's sides,
> The girth of it and the wharf of it and the wall;
> Stanching, quenching ocean of a motionable mind;
> Ground of being, and granite of it: past all
> Grasp God, throned behind
> Death with a sovereignty that heeds but hides, bodes but abides.

Likewise human beings often figure in Hopkins' poetry as "motionable" fluids. To refer to the stanza quoted above, Catherine Phillips interprets the phrase "ocean of a motionable mind" as meaning "the restlessness of men's minds" for which God, the seawall, supplies a structural bound or form-giving limitation (Phillips 341 n.118).

In his poems, and particularly in his great *Deutschland* ode, Hopkins repeatedly identifies humanity with waves of energy and God as the structuring, bounding “wharf” or “wall” that shapes human energy and gives it form.[152] In life, God is a salutary and supportive wall, one that supplies structure and consistency to human energy. But for the damned in the afterlife, God is an imprisoning wall, reflecting the soul’s energy not benevolently, to fruitful pursuits, but punitively, to pound against the scapes of its past sins.

If God’s wrath is a wall of countermanding force that reflects the soul’s instress back upon itself, then Hopkins shows spiritual energies obeying the same laws that preside over physical relations. Much as a wave of water rebounds via mechanical reflection from a seawall, or much as a wave of sound rebounds from a wall as an echo, so the condemned soul’s energy rebounds from God’s wrath. Hopkins’ conceit is admittedly analogical here. But for Hopkins, analogy does not suggest surface similarity despite ontological difference. Rather, for Hopkins, analogy reveals underlying ontological correspondence made evident by apparent similarity.[153] Things that are analogous belong to the same order, and apparent similarity reveals ontological unity.

Finally, how does an instressed scape result in fire, and what is the nature of this fire, given that “it is by [. . .] the imagination that the lost suffer” it (136)? Hopkins claims that when the soul’s stress is reflected back from God’s wrath, it engenders “[textural] stress” within the substance of the soul (136). As he describes at the end of his commentary, two stresses are at work in the fibers of the soul’s substance. On the one hand, Hopkins describes the natural bent of

[152] A wave of water is a wave of energy. The water is merely the medium for the wave – the energy within the watery medium is responsible for the wave-like undulations. The same applies to sound in air, or any other compression wave in a medium.
[153] In Scotist terms, I might say that formalitas implies haeccitas. In Hopkins’ terms, I might say that inscape implies essence or being.

the soul's energy outward, toward objects and "natural activities" (138). On the other hand, Hopkins describes the confining stress of God's anger forcing the soul's agency back within itself. As Hopkins writes, "the one stress or strain then encountered and clashed with the other" within the tissues of the soul's substance, creating textural stress or friction within it (138). Fire is the natural result of friction (see Brown 275). More than this, however, the soul's returning stress, reflected by God's anger, bores and drills into the scapes of its sin as the imprisoned soul instresses its past misdeeds: "against these acts of its own the lost spirit dashes itself like a caged bear and is in prison, violently instresses them and burns, stares into them and is the deeper darkened" (138).

But what of the "imaginati[ve]" nature of hell's pains? Surely, one might argue, if the pain is imaginative, then it cannot be actual or substantial. By this argument, the pain must be psychological, and what Hopkins really means is that the guilty soul reflects upon its misdeeds, and feels remorse and loathing for them. Thus, one might say, the soul feels such mental anguish that it is as if it has been set on fire. "Pain" and "fire" then are mere metaphors for psychological distress.

Several aspects of Hopkins' commentary make this interpretation persuasive. Hopkins observes that the lost in their "present condition [. . .] are disembodied" (136). Likewise, Hopkins remarks that the reason why Ignatius "speaks only of the pain of sense" in his description of hell is that "sensible considerations" are the most likely to "deter us from sin" (136). Presumably, Ignatius is motivated primarily to elicit the proper moral response from exercitants, and uses creative license to do so. Ignatius delineates hell in physical and sensory terms because these terms most successfully stimulate the desired reaction. Furthermore, Hopkins notes that Ignatius "mingles without reserve or remark physical and figurative things, like brimstone and tears (which the disembodied soul cannot shed) and the worm of conscience" (136). Apparently, then, the fires and physically sensuous pains that Ignatius describes exist in no more real a sense than the figurative elements (brimstone, disembodied tears, and the worm of conscience) do. In light of such considerations, Hopkins concludes that "as it is by the imagination that [exercitants] are to realize these things so I suppose it to be by the imagination that the lost suffer them and that as intensely as by the senses or it may be more so" (136). Much as an excercitant "feels" hells pains imaginatively, so the damned feel pain in the same way in their disembodied state.

At this point, Hopkins declares that his "simple explanation" of the source of pain in hell "will never strike our scholastics, because they do not see that there is an intellectual imagination" (136). Most likely, by "intellectual imagination" Hopkins means the Romantic "intellectual intuition" or the Coleridgean secondary imagination, which sorts and reassembles prior sensation in order to create a new reality. Hell for the condemned, then, is the continuous overflow of painful feelings at the recollection of deeds done in life. Likewise, the Ignatian excercitant must also select and rearrange prior sensuous experience to posit hell. In this way, hell, whether projected by the exercitant or experienced by the condemned, is a product of the imaginative faculty.

Had Hopkins stopped there, hell's pains would be purely mental creations devoid of substantial objectivity. But Hopkins doesn't stop there. Instead, he continues to set even the imagination on a substantial basis. While I have here reserved discussing hell as an imaginative product until after I had discussed scapes, textural stress, the field of God's wrath, and the field of the soul's energy, the order of my discussion opposes that of Hopkins'. Hopkins first contemplates hell as an imaginative product, and then analyzes scapes, stresses, and fields to account for the way the imagination works. As I will argue below, for Hopkins and for Victorians generally, the memory, imagination, and other mental faculties were materially embodied within the brain. Thus memories and impressions are inextricable from the medullary structures within the brain ("scapes," Hopkins calls them) that house and preserve them. As I will also argue below, in positing the soul, Hopkins extends from bodily substance, and considers the soul as substantially equivalent to the material body. If memories within the physical brain take the form of material "scapes," then the soul's misdeeds are similarly etched within its substance. Localized within brain, memory and imagination in an embodied human being result from physical processes, or from the interactions of energy and matter in the brain. Much the same, the memories and imagination within the soul result from similar physical processes, or from the interactions of energy and immaterial substance within the soul's being. Hopkins grounds imagination in substance, then, and the operation of the imagination depends upon the scapes, fields, and forces that he subsequently describes.

To summarize Hopkins' account, the soul in life exerts a field of energy outward from itself, "towards being, towards good, towards God" (137). In hell, however, this outward-tending field meets the opposed field of God's wrath, which forcibly throws the soul's energy "back upon the soul itself," to bore into its substance and the scapes of past misdeeds housed within that substance (137). Strained internally by the conflict between its outwardly-oriented stress and God's punitive compression, the soul experiences internal friction and combusts.

Hopkins' causal theory of hellfire is evidently speculative, and it may be tempting to dismiss his language of physics and energy as merely analogical. To strip his meditation of all figurative analogies, Hopkins presents hell as an intense and eternally-prolonged period of introspective remembrance. The soul feels pain as it reflects upon the misdeeds committed in life. But to strip the analogy is to miss the point. Not only does such a stripped-down hermeneutic eliminate the objective reality of God's wrath and the damned soul's torment, but it also misses a recurring feature of Hopkins' figurative language. Hopkins' analogies reflect from surface likeness to ontological congruence. In setting up the soul's energy and God's anger as analogous to forms of energy that operate in the visible world, Hopkins implies the similarity and compatibility of spiritual and physical energy. In short, spiritual energies of the soul's stress and God's outstress in nature are yet more forms of the various manifestations of energy in the total universe.

In the previous chapter, I argued that Hopkins' comparisons between natural and spiritual energies are more than metaphorical. In sum, I suggested that Hopkins viewed the spiritual and the material as inhabiting a single, integrated universe, and considered energy to be subtle enough to communicate spirit to matter and matter to spirit. In the following sections of the present chapter, I will compare Hopkins' psychology and pneumatology to nineteenth century brain and aether science. First, I will attempt to show that according to nineteenth century psychology, the forms of energy that act within the brain to produce thought are identical to those that act in nature to produce the phenomena of the physical world. Second, I will analyze Hopkins' treatment of the soul and the afterlife to assess the applicability, for Hopkins and for scientifically-minded Victorians, of the physical science of energetics to the unseen world.

5.3 Aethers and Brain Science: Victorian Physiology and Psychology

Victorian psychology has deep roots in aether theory and Galenic physiology. Consequently, discussing Victorian psychologists' poise between physics and metaphysics requires a brief excursion into the longer history of aether and the Galenic "subtle fluids." Aether, for the Greek atomists, was a highly rarified substance. While the Greek atomists contradicted each other freely, aether was often identified with the rarest element of matter (either fire or air, depending on the philosopher), or formed a fifth element of the most finely subtle matter possible. As the most highly refined element, aether was typically associated by the Greek atomists with the celestial heavens, the spirit, or even Reason itself. Aether provided, in effect, a site of transfer between matter and soul.[154]

In Western physics during the Enlightenment period, aether once more occupied a limbo-land between matter (which, for theological reasons, was viewed as motionless and dead) and the life-giving and motion-imparting spirit.[155] To take Newton's 1717 *Optics* as an authoritative instance, Newton reasoned that matter is inert. It possesses no force within itself, and all motion must be imparted from without. Since all movement and motion ultimately stem from God, matter has no agency, nor any active properties.

The problem with this was that Newton viewed gravity as an "active principle" (*Optics*, query 31). How could dead, inert matter produce gravity if gravity is an active principle? Enter

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[154] The nature of this "site of transfer" differs depending on author. In later philosophy, dichotomists often treated the aether as an intermediary between matter and soul, a matter fine enough to be susceptible to the soul's motions yet dense enough to communicate movement to gross matter. See my discussion of Newton, below. For monists, however, aether (or a highly rarified matter like aether) was at times identified as the actual stuff of the soul and of angelic bodies, as in the case of Milton's aetherial angelic bodies in *Paradise Lost*. Yet even though aether permits various application, and may fit a dichotomist as well as a monist ontology, it tends to set dichotomism in dialogue with monism. Introducing aether to a dichotomist ontology renders the division between material and immaterial contestable. For further discussion of this, please see G.N. Cantor and M.J.S. Hodge's remarks on the Stahl-Hoffman controversy in the introduction of their edited volume (28-29), as well as Roger French's article in the same volume.

[155] In the interest of brevity, I am skipping over the aethers and spirits of Galenic physiology that were ubiquitous in medieval and early modern medicine. Nevertheless, as we will see in the instance of Newton, many Enlightenment natural philosophers adapted the Galenic "subtle fluids" to explain the soul's ability to move the body. I am also skipping over several influential natural philosophers (Descartes and Boerhaave particularly) whose writings, along with Newton's, helped to establish aether as an important element of Enlightenment science. My reason for focusing on Newton particularly is that Hartley and the later associationists treated his theories with especial deference, and proposed their own ideas as extensions of his.

aether: For Newton, aether generates gravity by repelling particles of matter. Accordingly, aether is a special "matter" for Newton in that it possesses active agency. Aether and mundane matter represent two separate orders of material substance, then, a higher and a lower order. While the lower order of mundane matter remains inert and passive, the higher order of aether aspires to immaterial substance in its possession of qualities (activity, motion) that Newton typically reserves for spirit. In a loose and uncertain fashion that Newton never explained, aether is allied with the spirit and with life, and even with God himself. As P.M. Heimann writes, "Newton conceived the ether of the 1717 *Optics* as an active principle communicating God's causal agency" to his creation (66). In other words, the aether acts as an intermediary between God and his creation, translating God's power into a form of physical force that can act upon inert matter.

From Newton's *Optics*, aether functions as an invisible, intangible, highly-rarified substance that spans the universe and communicates God's life-giving force and motion to gross matter. But aether for Newton is immanent as well as transcendent, and while it spans the universe, it also inhabits each living being. To be more precise, Newton did not believe in a single, uniform aether. In his "An Hypothesis Explaining the Properties of Light," Newton argues that "it is not to be supposed, that this medium [the "common aether"] is one uniform matter, but compounded, partly of the main phlegmatic body of æther, partly of other various æthereal spirits" (250). Newton further distinguished the "common æther" and the "ætherial animal spirit."[156] The animal spirit is a subtle fluid resident within the brain and nerves of the

[156] Note that "spirit" is an semi-intentional pun. Newton and his physiological predecessors intended "spirit" to designate a finely subtle fluid or vapor. However, the "animal spirit's" close relationship with the soul suggests additional meanings. As Robert K. French writes, the animal spirit is a "barely material spirit in the nerves" (112). According to French, Aristotelian physiologists equated the fluid animal spirit with Aristotle's *pneuma*. French explains, "this *pneuma* was an active subtle fluid far removed from the elements of the mundane world but related to the ether of the heavens" (112).

body. At the soul's instigation, the fluid animal spirit moves into and out of the muscles, making them more or less "sociable" to the common æther (253-4). A muscle that is "sociable" to the common aether attracts the aether, and consequently swells and contracts. Contrarily, common aether abandons an "unsociable" muscle, which consequently shrinks and relaxes. In effect, the soul controls the movement of the aetherial animal spirit within the body; the aetherial animal spirit controls the movement of the common aether into and out of the muscles; and the common aether acts upon the muscles to produce contraction and movement.

Newton's interpretation of sight resembles his account of muscular movement. Once more, aether provides the necessary link between the soul's volition and body's response. Geoffrey Cantor summarizes Newton's theory, explaining,

> In his account of vision, Newton suggested that rays of light falling on the retina cause this medullary ether to vibrate, and this vibration is then transmitted along the optic nerve 'into the place of sensation' [the brain]. Likewise, in explaining how we move parts of our bodies, Newton considered that the 'power of the Will' causes the ether in the brain to vibrate. This vibration in the medullary ether is then propagated along the capillaries of the nerves and produces movement through either contraction or dilation of the muscles. Both of these explanations were based on the hypothesis that Newton's ether could interact with both matter and mind. (145)

Thus aether translates God's power to creation in the form of gravity, and conveys the soul's motions to the body as medullary vibrations. In both cases, Newton's aether mediates the metaphysical and the physical, and translates the living motions of spirit to the inert mass of matter.

Poised between mundane matter and immaterial substance, the physiological aethers of Newton and many of his contemporaries "somehow partook of the immateriality of the soul and of the materiality of the body" (French 111). Thus, Newton posited the semi-material "animal spirit" as an adjunct of the soul, a helpmate to do the soul's bidding. Yet subsequent physiologists attributed more and more agency to matter, and depicted the physiological aether as increasingly material. Eventually, David Hartley would propose a physiological aether that, while ostensibly mediating between soul and matter, effectively explained sensation and thought in material terms independently of the soul.

In several facets, Hartley's aether extends from Newton's. Like Newton's aether, Hartley's aether is intimately associated with the interior medullary substance of the nerves. Similarly, Hartley follows Newton in proposing that vibrations in the medullary aether convey sensation from the sensory organs to the brain. As Hartley explains, "when external objects are impressed on the sensory nerves, they excite vibrations" both in the medullary particles of the nerves themselves as well as "in the aether residing in the pores of these nerves" (21). Subsequently, "the vibrations thus excited in the aether, and particles of the sensory nerves, will be propagated along the course of these nerves up to the brain" (23).[157]

At this point, however, Hartley diverges from Newton. For Newton, aether mediates body and soul, and explains how the motions of the metaphysical soul may be communicated to the gross matter of the mortal body. Hartley, in contrast, employs the vibratory aether to transfer

[157] Hartley's theory of muscular contraction is similar to Newton's as well in that it depends on vibration within the medullary aether to stimulate the muscles to contract. As Hartley writes, "muscular motion is performed by vibrations also" (91). The brain propagates a vibration which "descends along the motory nerves" to the muscles (91). "These vibrations, when they arrive at the muscular fibres, are communicated to them, so that the small particles of these fibres shall be agitated with like vibrations. [. . .] The vibrations thus excited in the fibres, put into action an attractive virtue" which causes the muscle to contract (91). Again, however, where Newton specifies the soul or the will as the source of the aetherial vibration, Hartley specifies the brain.

sensory information from body to brain, and motor commands from brain to body. While Hartley remarks that the traditional role of aether in mediating soul and body "appears to be no improbable supposition," the bulk of his work addresses the brain, not the soul, as the center of sensation, thought, and volition (34). To be fair, Hartley himself professes belief in the soul, and views the brain as the "seat of the rational soul" (84). However, as Geoffrey Cantor observes, Hartley's conservative readers objected to what they perceived as the "atheistic implications of Hartley's fully-fledged system" (146). Hartley's personal piety notwithstanding, his system makes possible a material account of sensation and volition that renders the soul adventitious.

Hartley's explanation of ideas and mental dispositions was perhaps the most subversive element of his theory. As Hartley explains, "as soon as the [sensory] vibrations enter the brain, they begin to be propagated freely every way over the whole medullary substance; being diminished in strength, in proportion to the quantity of matter agitated" (24). Within the nerve itself, the vibrations are tightly constricted, and are consequently forceful and energetic. When introduced to the brain, however, the motive force of the vibrating particles disperses throughout the entire mass of the brain. Much like a rock thrown into a pond, the initial splash the vibration makes upon reaching the brain attenuates as ripples that spread throughout the brain.

But if "vigorously impressed" or "frequently renewed," a sensory vibration can set the entire mass of the brain in vibration, and create a stable ripple or "vibratiuncle" in the medullary aether of the brain.[158] Hartley refers to such a ripple stemming from sensory vibration as an "idea

[158] For most philosophers, aether's extreme subtlety and rarefaction inhibit viscosity and friction. Consequently, vibrations in aether, once begun, enjoy a degree of stability and longevity unimaginable in frictional substances. The fact that Hartley's vibratiuncles are stable and long-lasting suggests that his aether is also nearly frictionless. Apparently, however, some friction persists in his aether since he describes minute sensory vibrations as fading away over time. On the other hand, perhaps these small vibrations fade away because they are cancelled by or subsumed within larger ones.

of sensation" (58). This "idea of sensation" is "the [copy] and [offspring] of the impressions made on the eye and ear" (58). In its most simple form, an "idea of sensation" is what Hopkins might call a scape, a physical arrangement of the material substance of the brain (aether, in Hartley's case) which encodes sensory experience.[159] But ideas of sensation stemming from single sensations are typically weak, and their ripple in the aether-lake of the brain quickly fades. However, if the experience causing the "idea of sensation" is repeated, the resulting ripple in the brain will gather force as if through harmonic resonance. Thus, simple sensory vibrations cooperate to amplify the vibratiuncle, and at length create a large enough ripple to establish a lasting brain-wave -- a "disposition." Each time a person experiences a particular sensation, or each time a person experiences an event sufficiently similar to the original sensation, the new sensory vibrations amplify the existing wave in the mind.

Ideas of sensation compound and associate within the brain, giving rise to increasingly complex ideas, including intellectual ideas and propositions. At length, the signature vibrations within the brain become stable enough to condition the nature and function of the brain (66). Thus, Hartley offers a physical model to explain how sensation begets ideas, ideas beget concepts, concepts beget habits of thought, and habits of thought beget personality. Stripped of its physical apparatus of aether, nerves, vibrations, vibratiuncles, and dispositions, Hartley's theory advances a Lockean history of mind in which sensation ultimately generates personality. But stripping Hartley's theory of its physical apparatus misses the point and purpose of the theory itself. Hartley intends not merely to argue that sensation generates personality. Instead, he

[159] In other words, Hartley's "idea of sensation" is not the initial sensation itself, but a memory of the sensation. But note that memory for Hartley is a product of the physical arrangement and conditions of matter in the brain. Hartley is not merely interested in the relationship between sensation and memory. Rather, he is interested in the way memory is materially generated within the mind. In effect, Hartley creates a physical model of memory in which memories are peculiar vibrations of aether within the brain.

intends to inquire into the material processes of embodied mind – the brain – and to build a model of the processes by which sensation compounds and aggregates. The physical analogy is not ancillary but central.

Hartley's physical analogy was also controversial. Orthodox philosophers typically reserved sensation, thought, and personality as the province of the soul. By Hartley's theory, however, these activities fall under the domain of physical, embodied experience. Even more, if each thing in nature possesses its own proper vibration, and if the organs of sense transmit this proper vibration to the nerves and the brain, then the nervous system vibrates in unison with its external objects. In other words, a percipient subject responds to and becomes similar to the objects of sense it observes. Essentially, vibratiuncles dispose (or "pitch," as Hopkins might say) the mind in tune with external objects.[160] So pitched, the mind takes the character of its environment, and a person's sensory objects define his or her nature.[161]

Alan Richardson explores the symbiosis of Hartley's associative psychology and radical religion, politics, and materialism during the latter eighteenth and early nineteenth centuries. As Richardson relates, Hartley stands at the head of a trend of "Romantic brain science" that was perceived to challenge not only the soul but also the English political order:

[160] Readers may notice that I apply several words ("scape" and "pitch") from Hopkins' distinctive idiolect to Hartley's theory. My usage of these words is admittedly anachronous, but the anachronism does suggest, initially at least, several points of contact between Hartley's associationist psychology and the Victorian psychology of Hopkins' time. I will shortly discuss these points of contact in further detail.

[161] With Hopkins in view, I might add that Hopkins' concept of instress restores an element of freedom to associationist psychology. Hartley's psychology led him to Necessitarianism, given that the objects of sense condition the mind. Hopkins, however, observed that one's nature depends not on the innumerable objects of sensation, but on the limited number of objects one chooses to "instress." Thus, Satan's sin was to "instress his own inscape," or to willfully fix his mental energies on himself instead of his Creator.

> The Church and King riots of 1791, in which a "loyalist" mob had invaded Priestley's home and destroyed his scientific equipment, had demonstrated a connection even in the popular mind between political radicalism and unorthodox science at the very beginning of the period of anti-jacobin reaction. By the early nineteenth century, any theory that 'so much as hinted' that the mind arose from 'corporeal organization' was branded as 'atheistical and politically subversive,' in other words, 'French-inspired'" (15).

Richardson's analysis compresses a number of cultural currents of the Romantic revolutionary period. First, if the brain could be proven to be the seat of activities typically reserved for the soul -- reason, thought, emotion, sensation – then the soul could be dismissed as superfluous. With the soul, the doctrines of the established church could also be dismissed, particularly those pertaining to creation, the afterlife, and potentially God himself. Second, since the Anglican Church was a fixture of the political monarchy, to set aside the church, or at least the teachings of the church, was tantamount to setting aside the authority of the head of the Anglican Church, the king himself. Third, the revolution of reason in France had similarly banished God and the king in favor of a more rational system of political and religious belief. For "loyalist" Englishmen, then, any brain-based challenge to the soul ultimately signaled a challenge to God's and the king's sovereignty. In short, brain-based science smacked at once of materialism, atheism, and political subversion – in a word, of Jacobinism. Accordingly, in the late eighteenth and early nineteenth centuries, physiologists such as Erasmus Darwin, F.J. Gall, Pierre-Jean-George Cabanis, J.G. Spurzheim, Sir William Lawrence, and George Combe were derided in the British popular press for the religious implications – and the perceived political implications – of their theories (Richardson 5).[162]

Yet despite social and religious impediments, psychological and physiological research flourished apace. Erasmus Darwin revised Hartley's theory, replacing Hartley's passive, receptive sensation with an active sensorium.[163] As Darwin saw, impressions may stem from external objects, but the sensorium augments and arranges impressions to generate the reality one perceives. To prove his claim, Darwin discusses a number of optical illusions, arguing that they demonstrate the sensorium's activity in organizing impressions.[164]

Yet while Darwin considered the arrangement of sensation to be the prerogative of the extended or total sensorium, other investigators focused on the brain specifically. Cabanis located perception within the brain, claiming that the brain "digests" sensation furnished by the

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[162] Charles Bell, although he taught that the brain was the seat of mental activity, escaped outrage for the most part because of his reputation for personal piety and his avowed belief in the soul.

[163] Darwin's sensorium included all nervous medullary matter throughout a person's body (whether in the brain, nerves, sensory organs, or muscles) as well as a "sensorial fluid" akin to Hartley's aether or Newton's aetherial animal spirit. As Darwin defines, "the word *sensorium* in the following pages is designated to express not only the medullary part of the brain, spinal marrow, nerves, organs of sense and of the muscles; but also at the same time that living principle, or spirit of animation, which resides throughout the body" (Darwin 5). While Darwin's "living principle or spirit of animation" may have been understood by dualist readers to mean the soul, Darwin most likely intended it to mean a subtle fluid. Again, "spirit" was a problematic word during the seventeenth and eighteenth centuries.

[164] At one point, Darwin directs his readers to spin around and around until dizzy, and then to stop suddenly (12). Darwin observes to his readers that although they have stopped spinning, they will briefly see the external world wheel around as if they had not stopped. Darwin argues that this proves the sensorium's activity in arranging perceptions. Although the reader has stopped spinning, the reader's sensorium (his eye, according to Darwin) projects a spinning motion upon the field of vision.

Darwin's interest in the body's role in perception was part of a larger trend that spanned scientific and aesthetic literature during the nineteenth century. Richardson notes that Wordsworth also wrote about this phenomenon("Stopped short; yet still the solitary cliffs/ Wheeled by me – even as if the earth had rolled/ With visible motion her diurnal round") (Richardson 13; Wordworth, *Prelude* 458-60). Similarly, the brain's role in perception is a consistent theme in Hopkins' poems, undergraduate essays, and journals. Please see my discussion, below, of the brain's role in "forestalling" an object.

sensory and bodily organs. Nevertheless, given that the brain is bodily itself, and given that it receives input (much of which, as unconscious, eludes rational control) from the body, the bodily appetites condition the brain. Accordingly, human knowledge is conditioned by embodied experience and desire.

Still other investigators considered the structure of the brain. The anatomist F.J. Gall, for instance, along with his student J.G. Spurzheim, dissected brains to discover their modular or "organic" formation. Instead of a single undifferentiated mass, the brain contains discrete organs, each of which controls a specific aspect of human behavior. Gall and Spurzheim argued that personality depends on the development of the organs within the brain. Overdevelopment or underdevelopment of a region within the brain leads to particular personality characteristics and deficits, including criminality and mental illness. With such claims, Gall and Spurzheim initiated the study of craniology, from which phrenology would stem later in the century.

Physiologists in the Victorian era continued in much the same vein as their Romantic counterparts. Late nineteenth century physiologists such as John Hughlings Jackson, David Ferrier, Eduard Hitzig, Gustav Frisch, and others worked to map the regions of the brain, incited by their conviction that each of the brain's functions could be identified with a specific anatomical location. Mapping the regions of the brain required dissection. Moreover, electrically stimulating the brain required live test subjects. Even more, since unconscious brains respond differently to stimulation than conscious ones do, physiologists like David Ferrier "began studying animals that had awakened from anesthesia" and were conscious (Otis 29). Consequently, in the latter decades of the nineteenth century, brain research stimulated the Antivivisection League, and, according to Laura Otis, Ferrier's research particularly figured in

Wilkie Collin's *Heart and Science* and H.G. Well's nightmarish novel of vivisection, *The Island of Dr. Moreau*.

Through the nineteenth century, sectors of the British populace resisted physiological research on religious, political, philosophical, and – lastly – humane grounds. Nevertheless, several scientific developments aided it, particularly those in electrophysiology. As Richardson writes, "most important in establishing the new climate was Galvani's demonstration of 'animal electricity,' which he described in print first in 1791" (7). Among the commonalities that unite the radical brain scientists of the late eighteenth and early nineteenth centuries, Richardson lists the fact that "they all stress the complexity of the brain [. . .] and exhibit a cautious fascination with the role of electricity in neural transmission" (6).

Aether and electricity were traditionally associated since at least the time of Newton. Electricity, like aether, was typically referred to as one of the "subtle fluids." Hartley himself, in his *Observations of Man*, remarks that "the emission [. . .] electrical effluvia, may also be some presumption in favor of the existence of the aether" (15). Consequently, when the physiologists of the early nineteenth century cautiously identified electricity as the active principle of the nerves, they were not so much overturning Newton's and Hartley's assertion of a subtle medullary fluid as they were confirming it and refining it. For the early nineteenth century philosophers, if electricity was not one of the aetherial fluids in itself, then at the least it was regarded as closely associated with the aether.[165] Given that the physiologists of the early

[165] Although this conception would be revised throughout the nineteenth century, electricity nevertheless retained its associations with the aether. By the middle to late nineteenth century, philosophers like Thomson and Maxwell regarded electricity not as a variety of aetherial fluid but as a form of energy transmitted by the aether.

nineteenth century depict electricity as a subtle fluid within the medullary nerves, their descriptions of electricity follow from Newton's and Hartley's descriptions of aether.[166]

As the nineteenth century progressed, it became increasingly probable that the subtle nervous fluid within the medullary nerves was none other than electricity. Beginning in 1791, Luigi Galvani and his nephew Giovanni Aldini demonstrated that the application of electricity to the brain of a recently killed animal (or executed criminal) could produce twitching and contortion of its limbs.[167] Such grisly experiments entered the popular imagination. As Richardson notes, no frogs were safe: Galvani's experiments were "replicated by an eager public 'wherever frogs were to be found'" (Richardson 7). Such experiments implied that electricity not only stimulated the muscles and nerves, but that it was intrinsically associated with the life of the body. Anne K. Mellor, in her interpretation of Mary Shelley's *Frankenstein* as a "feminist critique of science," argues that the monster Frankenstein's gruesome electrical vivification criticizes the unnatural experimental techniques of contemporary scientists, most notably Galvani and Humphrey Davy (89). Yet In addition to critiquing science, Shelley's novel also attests the popular fascination with Galvanic electrostimulation, and with electricity's role in animating the body through the conduits of the nerves.

During the Victorian era, the number of natural philosophers and physiologists espousing the electrical function of the nerves multiplied. Briefly to list a few, Hermann Helmholtz in 1847 "measured the speed of nerve conduction [in frogs] and equated it with electricity" (Kennaway 142). Similarly, beginning in 1848, Emil du Bois-Reymond "posited that [an electrical] current

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[166] As Richardson writes, however, the late 18th and early nineteenth century physiologists did not agree with Hartley and Newton in all points. Specifically, they "depart[ed] from Hartley and Locke" in positing "a biological rather than mechanistic conception of physiological and mental functioning" (6).

[167] In 1803, Giovanni Aldini employed his uncle's technique of electrostimulation on George Forster, a criminal who had been previously executed for murdering his wife and child.

flowed continually in the fibers of muscle and nerves" (Matus 174). In 1862, Guillame Duchenne published *The Mechanism of Human Facial Expression*, complete with photographs of test subjects whose facial muscles Duchenne had distorted through the application of electrical probes. Likewise, in an 1867 work on nervous shock, Edwin Morris wrote that he was "inclined to believe that [nervous shock] is of the same nature as electricity, and the nerves act as conductors" (11). In 1870, Gustave Fritsch and Eduard Hitzig "applied current to the exposed brains of dogs and produced 'combined muscular contractions on the opposite side of the body'" (Otis 29). Alexander Bain, in his 1873 treatise *Mind and Body: The Theories of Their Relation*, observes that narcotic stimulants "expend our stock of power in nerve-electricity in a higher degree [. . .] than the ordinary stimulants of the sense" (73). Most notoriously, in 1873 David Ferrier began his course of vivisection and electrostimulation that would so incite Victorian ire.

By the 1870s, the material basis of mind was well established. In an article written for the October 1874 issue of *Popular Science Monthly,* the anatomist T.H. Huxley declared, "It is not to be doubted that those motions which give rise to sensation leave on the brain changes of its substance [. . . .] The sensation which has passed away leaves behind molecules of the brain competent to its reproduction – 'sensigenous molecules,' so to speak – which constitute the physical foundation of memory" (731). To educated Victorians, physiological research suggested that sensation, movement, thought, memory, personality, and even the will may or may not have anything to do with the soul, but they have everything to do with the brain. Thought was less certainly a matter of the soul, and more certainly a matter of a specific form of energy – electricity – at work in a specific region of the brain. In all, a memory or a thought could be conceived less as an act and more as a material object. Instead of an arcane activity of the soul, a thought could be a defined as a physical arrangement of matter and energy within the schematized space of the brain. As Laura Otis writes, part of what motivated the antivivisectionists at the end of the century was the implicit claim of physiological research that "electricity could replace a creature's will. Perhaps [. . .] there was nothing sacred about the human will, or even the human consciousness" (Otis 31).

Popular literature attests educated Victorians' awareness of physiological developments. Given the notoriety of physiological brain science, and given the anti-Jacobin and antivivisectionist controversies to which it contributed on either end of the nineteenth century, materialist accounts of thought within the popular literature of the period should be expected. Richardson traces materialist accounts of thought in the works and writings of William Wordsworth, Samuel Taylor Coleridge, John Keats, and Jane Austen. His analysis of Keat's *Fall of Hyperion* is particularly striking, given that the poem displays a medical student's knowledge of both anatomy (Moneta's 'globed brain') and electrophysiology (the 'scenes' or memories in Moneta's brain '[swoon] [. . .] with an electrical changing misery') (Richardson 124).

Walter Pater's conclusion of *The Renaissance* (1873) suggests an analogous understanding of the brain's physical structure and electrical operation. In his conclusion, Pater asserts that "our physical life is a perpetual motion" of the natural elements of nature, "phosphorous and lime and delicate fibres" (207). Immediately after this assertion, Pater explains "Our physical life is a perpetual motion of [these elements] – the passage of the blood, the wasting and repairing of the lenses of the eye, the modification of the tissues of the brain by every ray of light and sound – processes which science reduces to simpler and more elementary forces" (207). By this explanation, not only does sensation occur as a material process within the brain, but each individual sensation "leaves its mark on mind" (as Hopkins might say) or generates a physical "scape" within the brain: "every ray of light and sound" causes a “modification of the tissues of the brain” (207). In accord with associationist psychology, Pater’s “ray[s] of light and sound” are physically translated by the nerves to the brain, where they are physically inscribed within the brain’s tissue. Moreover, science “reduces [this process of inscription] to simpler and more elementary forces” (207). While Pater does not name electricity specifically, his description of mental processes occurring through the operation of physical, “elementary forces” certainly chimes with the electrical researches Romantic and Victorian physiologists such as Galvani, Fritsch, Hitzig, and Ferrier.

Comparably, in Balfour Stewart and Norman Lockyer’s “The Sun as a Type of the Material Universe,” Barri Gold notes a similarly materialist analogy between events within and without the human brain (Gold 131-49). Gold notes that in Stewart and Lockyer’s article, the pair address the tendency of energetic causes to compound, or for a small amount of initial energy (what would now be called “activation energy”) to produce large changes. Stewart and Lockyer illustrate their claims with various instances of exploding “chambers” touched off by small causes: A gun may be touched off with a hair trigger, a canon with a ripcord, a gunpowder magazine with an electrical wire. In each of these examples, an energetic chamber is set off by a small investment of initial energy. Subsequently, however, Stewart and Lockyer come to another “chamber”: the human mind. In Lockyer and Stewart’s words, “We see how from an exceedingly small primordial impulse great and visible results are produced. In the mysterious brain chamber of the solitary student we conceive some obscure transmutation of energy” (326-7). Although this “transmutation of energy” is “obscure,” it consists of energy nevertheless, and much as the sparking of a gun, canon, or battery is a matter of physical energy, so is thought within the human brain. Additionally, much as the spark that ignites a gun or battery produces an effect proportionally much greater than itself, so do the sparks within the brain. Thus, Lockyer and

Stewart explain, the “obscure transmutation of energy” in the “brain chamber of the solitary student” produces nothing short of the industrial revolution. The solitary student (apparently James Watt) has grasped “the transcendent power of steam as a motive agent” (326). From the scene of the spark inside Watt’s brain chamber, “the scene widens, and as we proceed, a solitary engine is seen to be performing, and in a laborious way converting heat into work; we proceed further and further until the prospect expands into a scene of glorious triumph, and the imperceptible streamlet of thought that rose so obscurely has welled into a mighty river, on which all the projects of humanity are embarked” (326-7).[168]

To come to Hopkins himself, several features of Hopkins’ writing show him responding to materialist trends in contemporary physiology: 1) His interest in the ability of the mind to construct reality; 2) His forthright references to “purely material psychology” and vibratory nerve impulses; and 3) His conception of the nature of the soul. Pertaining to the first feature, Hopkins’ letters, journals, essays, and poems frequently investigate optical illusions. To cite one instance from a multitude, in a June 25, 1873 journal entry, Hopkins describes watching a distant firework “pass the crest of Pendle” (Journal 232). For Hopkins, this was “curious,” because although his senses reported that the firework passed in front of the mountain, he knew that the mountain stood between him and the firework. Hopkins reasons that his vision “forestalled” the

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[168] Much as I have remarked in the previous chapter on the literal nature of Hopkins’ metaphorical analogies, Barri Gold remarks on the “the truth value of [Lockyer and Stewart’s] analogy” (134). As Gold elaborates, “in the course of their argument, Stewart and Lockyer also seem to partake of a principle that chaos theory calls ‘self-similarity,’ a principle that accounts for phenomena at vastly different scales looking very much alike” (134). Given that Lockyer and Stewart set the behavior of solar energy at one end of their scale, and the energy within the human brain at the other end, then their self-similar analogy sets solar and brain energy as material types of each other.

Other scientific authors of the time also considered the reliability of analogy. See particularly James Clerk Maxwell’s Cambridge paper, “Are There Real Analogies in Nature?”.

firework.[169] Although the firework should have disappeared from sight when it passed behind the bulk of the mountain, Hopkins' sensorium (specifically, his "eye") anticipated the firework's arc, projecting the image of the firework moving upon the backdrop of the mountain. In Hopkins' own words, "it may be because the eye taking up the well-marked motion and forestalling it carrys the bright scape of the present and past motion (which lasts 1/8 of a second, they say) on to a part of the field where the motion itself has not or will not come" (232).[170]

At various points, Hopkins refers to "purely material psychology" directly, such as in his Oxford essay "The probable future of metaphysics" (*Oxford Essays* 287). In this essay, Hopkins assesses the common fear that "the end of all metaphysics is at hand," and that "purely material psychology is the [conqueror] foretold and feared" (287). For Hopkins, such fears are "shortsighted" because "material explanation cannot be refined into explaining thought" (287). As Hopkins reasons, even if the claims of material psychologists and physiologists are true, "it is all to no purpose to show an organ for each faculty and a nerve vibrating for each idea, because this only shows in the last detail what broadly no one doubted, to wit that the activities of the spirit are conveyed in those of the body as scent is conveyed in spirits of wine, remaining still inexplicably distinct." In these words, Hopkins briefly distills the psychological model that had reached educated Victorians through Newton, Hartley, Gall, Spurzheim, and subsequent researchers. Hopkins' reference to "an organ for each faculty" recalls Gall's and Spurzheim's anatomical dissections of the brain, particularly their discovery that the brain consists of distinct

[169] By "stall," Hopkins means to position or to house. "Forestalling," then, means to position before or in front. In this instance, the firework, which was really located behind the mountain, was positioned in front of the mountain.

[170] Hopkins is also quick to point out optical illusions other than forestalling. For a signal discussion, see Hopkins' undergraduate essay "Causation," particularly his explanation of the quatrefoil/Maltese cross (*Oxford Essays* 200-2).

"organs," each of which corresponds to a mental faculty.[171] Likewise, his remark about "a nerve vibrating for each idea" stems from the associationist psychology articulated by Hartley in his theory of the vibratory medullary aether. Finally, in concluding that "the activities of the spirit are conveyed in those of the body as scent is conveyed in spirits of wine, remaining still inexplicably distinct," Hopkins recapitulates the pun on spirit characteristic of dualistic discourse since before the time of Newton (see footnote 13). In the first instance of the word "spirit" ("the activities of the spirit are conveyed in those of the body"), Hopkins means "the soul." But in the second instance of the word ("as scent is conveyed in spirits of wine"), Hopkins means a subtle fluid or vapor, like the fumes of wine or the "aetherial animal spirit" that mediated soul and body in Newton's physiological theory.

Finally, Hopkins' response to "material psychology" conditions his conception of the soul. Without a doubt, Hopkins was a Christian idealist who believed in the soul. However, as John Gordon explains, Hopkins "refute[s] the materialists [. . .] not by denying their findings but by extending them" (518). Hopkins' conception of the soul is informed by materialism, and draws from the psychology and physiology of his time (287). In "The probable future of metaphysics," Hopkins concedes that "psychology and physiology may withdraw to themselves everything that is special and detailed in the action of the mind" (287). In other words, thought is not the exclusive prerogative of the soul, and Hopkins allows for "an organ for each faculty" and "a nerve vibrating for each idea." Nevertheless, thought does not exist apart from the soul. In a subsequent corollary, Hopkins reasons that although evolution happens as Darwin describes, evolution is not "scopeless" or random (288). Rather, while evolution may seem "chromatic," as

[171] I do not mean to claim that Hopkins had read Gall or Spurzheim per se. Even had Hopkins never heard of the anatomical duo, he would certainly have known of craniology or phrenology. Even more, Gall and Spurzheim's theory of the brain as an assemblage of organs persisted well into the 1870s (and arguably the present), as the experiments of Ferrier, Fritsch, and Hitzig show.

a series of infinitesimal alterations generating blind and haphazard change, Hopkins predicts that subsequent developments of philosophy will show that "species are fixed [. . .] at definite distances" from each other (289, 290). Such determinate "fixing" of species implies a plan or Idea or Will that organizes the seemingly random progress of evolution. In a word, such a "fixing" of species requires God to superintend evolutionary development.[172] Thus, while Hopkins accedes to evolutionary development, he maintains that God, as the soul of the world, conveys his will within the (evolutionary) actions of the world. In much the same way, although human thought may be as thoroughly material as evolutionary processes, the human soul guides thought within the material brain much as God guides development in his material creation.

Yet while Hopkins preserves the soul and subordinates materialist discourse to orthodox idealism, he considered the biological mechanics of thought to be every bit as materialistic as contemporary physiologists and psychologists proposed. Consequently, Hopkins' description of the workings of imagination, memory, and thought should be considered in light of Victorian associationist psychology. More specifically, his keyword "scape" should be considered to mean not a disembodied act of soul, a thought or memory independent of the material brain, but an embodied arrangement of matter within the brain. Accordingly, in the following section I will address the material nature of scapes in Hopkins' model of hell.[173]

[172] For an incisive discussion of Hopkins "diatonic" or theistic model of evolution, see Cary Plotkin's "Towards a Poetics of Transcendence after Darwin: The Aspect of Nature."
[173] Admittedly, since Hopkins describes the state of disembodied souls in hell, my argument requires me to explain the ways the immaterial soul and material body correspond for Hopkins. I will attempt to do so in the penultimate section of this chapter. For now, I will repeat my previous claim that although the soul is immaterial, it is not insubstantial. If Hopkins perceives the laws of energy to apply to all substance universally (or if Hopkins considers the unseen world to belong to the same universe as the visible world), then similar relations should obtain between soul and body.

5.4 Scapes: A "Physical and Refined Energy Accenting the Nerves"

Hopkins' vision of the fallen angels and damned souls in hell exemplifies the physical metaphysics that animates so much of his poetry. In his vision of the damned, Hopkins theorizes that the fiery pain of hell stems from the instressed "species or scape" of past "bodily action[s]" and sensory impressions (*Sermons* 136). Hopkins cryptically explains that during life, the soul is "instressed *in* the species or scape of any bodily action (whether this gives rise to a physical and quantitative extension of its substance or not) and so *towards* the species or scape of any object, as of sight, sound, taste, smell" (*Sermons* 136-7, emphasis original). In this description, Hopkins assigns objectivity and physical permanence to two things that are normally considered either immaterial or transitory: memory (whether the "scape" of a "bodily action" or of an "object [. . .] of sight, sound, taste, smell"), and thought itself (136-7).

Hopkins' analysis of "scapes" in the present meditation recalls his earlier "All Words" essay defining the tripartite nature of a word. All words consist, Hopkins claims, of three "terms" or "moments": connotation, utterance, and application (*Essays,* 306). While the first and third terms in this lexical trinity are single in nature, the second term – utterance – consists of a hypostatic union. A word's utterance, Hopkins writes, involves at once of the "uttering of the [word's] idea in the mind," and the uttering of the word's sound with the mouth (*Essays,* 306). Regarding the idea in the mind, Hopkins makes yet another division, and from this term Hopkins derives two more, the word's "image" and its "conception." The word's image is the inchoate sensory impression on the speaker's mind that s/he attempts to communicate; the word's conception is the speaker's act of clothing or "fleshing out" the image with a specific word.[174]

[174] Hopkins meant his theory of language as an extended theological conceit of the Trinity and Incarnation. While the present chapter does not concern Hopkins' conceit per se, I have tried to reflect it in my choice of language.

Several associations – particularly the key word "scapes" -- unite Hopkins' description of a word's "image" in his "All Words" essay with his later description of the damned in his commentary on Ignatius' "A Meditation on Hell." In the "All Words" essay, Hopkins defines the word's image as the "sight or sound or scapes of the other senses" that reside in the speaker's mind and prompt selection of a word. But Hopkins is not content to assign the "scapes of the [. . .] senses" mere psychological or ideological reality. Instead, Hopkins converts the image/scape to physical and energetic terms, explaining that the image in the mind is "in fact physical and a refined energy accenting the nerves" (*Oxford Essays* 307). Thus, Hopkins represents the psychological image/scape in the mind as a physical artifact in the body, as a quantum of energy exciting the nerves of the body. Instead of presenting scapes as abstractions, Hopkins' pointedly demonstrates their physicality according to two criteria, substance and location. Of the image/scape's substance, Hopkins claims that it consists as a form of "refined energy"; of the image/scape's location, Hopkins claims that it resides in "the nerves" of the body (*Essays*, 307).

In fine, in his "All Words" essay, Hopkins equates the "scapes of the [. . .] senses" with images, originating from the various organs of sensation, that are stored in the brain as physical artifacts of past experience. As "a refined energy accenting the nerves," scapes/images are discrete arrangements of matter and energy (*Essays*, 307). Bound to a specific, physical location and consisting of a "refined," but definite form of energy, these images or scapes are "in fact physical" (304). Scapes are memories, then, but much more than mere memories: they are the physical remains of prior sensation housed within the nerves of the body. Thus, Hopkins' "scapes" equate to Huxley's "sensigenous molecules," or "the molecules of the brain competent to [an impression's] reproduction [. . .] which constitute the physical foundation of memory" (Huxley 731).

The foregoing discussion suggests that Hopkins treats the mind in physical terms. Mind and memory are not strictly immaterial, but take root in matter, specifically the gray matter of the brain. But this applies for the mind of an embodied human in earthly life. What of the mind and memory of the soul in the afterlife? How can the scapes of Hopkins' disembodied inmates of hell be substantial? Answering these questions requires attention to relationships contemporary Victorians saw between apparent and unapparent physical processes. As I shall investigate below, the Victorians considered the unseen world to be continuous with observable reality. For some, this unseen world included merely the microscopic domain of atoms and energy, while for others it stretched to the metaphysical domain of the soul and the afterlife. Whatever its extent, though, Victorians held the unseen universe to operate by the same laws of energy that govern visible phenomena. Furthermore, for those who included the traditionally metaphysical realm within the territory of the unseen universe, the scientific disciplines could be applied to interrogate immaterial substance. Given the continuity of existence, if the unseen universe existed substantially, then the laws and relations applicable to observable reality must also be applicable to it. Accordingly, in the follow sections of this chapter, I will trace several scientific Victorian projections as to the nature of unseen substance.

5.5 "Not Grossly Material": (Meta)physics and Imponderable Aethers

In the previous sections of this chapter, I have argued that Hopkins' psychology adhered to contemporary science in positing a material basis of thought. Hopkins, as a dualist, held that "the activities of the spirit are conveyed in those of the body" (*Oxford Essays* 287). However, he regarded memory or "scape"-formation, and presumably mental activity in general, as "in fact physical and a refined energy accenting the nerves" (*Oxford Essays* 287, 304). If the previous sections discussed the unity of natural and psychological energy, the present will discuss that of natural and spiritual energy. Hopkins treats spiritual forces as analogous to natural energies, but his treatment extends beyond metaphor to identification. Thus, the energies within nature do not merely resemble the workings of the metaphysical realm, but rather the forces within nature span the material world and the immaterial, and function in both spheres.

In Hopkins' writings, the relationship between material and immaterial being takes the form of two intercalated myths, the myths of the Great Sacrifice and the "diatonic" scale of being. In the former myth, after Christ's "procession" outward from the Trinity, he presses deeper and deeper into the "barren wilderness outside of God" (*Sermons* 197). In this procession, Christ passes downward through the ranks or "generations" of the various species of angelic being before reaching "the term of these generations [. . .] in a material or [. . .] earthy nature" (200). Thus, Christ proceeds progressively into the wilderness outside of God, descending through the angelic orders to assume a material human body. Matter falls beneath the angelic ranks, but matter and im-matter nevertheless coexist on the same scale of created being.

Moreover, this "scale" is musical at the same time that it is hierarchical. In his essay "The Probable Future of Metaphysics," Hopkins compares evolutionary species to notes on a "musical string" (*Oxford Essays* 289). Much as the notes on a scale or within a chord are "mathematically fixed" at definite intervals, so Hopkins conjectures that the species of earthly life produced by evolution are "fixed only at definite distances in the string" (289, 290). Hopkins continues, surmising that "the developing principle [i.e., evolution] will only act when the precise conditions are fulfilled" that will produce a new species at the appropriate place on the string of life (289, 290).

Yet the highest pitches in this musical scale are not produced by evolution, nor do they take the form of creatures with material bodies. Instead, the musical scale transposes to the register of immaterial being, and includes the angels as well. In his meditation on the Great Sacrifice, Hopkins likens the creation of the angelic ranks to a "concert of music, the ranks of the angelic hierarchies being like notes of a scale and a harmonic series" (*Sermons* 200). Christ "led off the angel choir" and the song he sings "call[s] [the angels] into being" (200). Unlike the species of earthly life, each angel is a species unto itself, and each is assigned "the note which summoned each to his own place and distributed them here and there in the liturgy of the [Great] sacrifice" (201).

Whether a ladder or a musical string, Hopkins' scale of being suggests continuity between matter and im-matter. Indeed, the world of matter recapitulates the higher octaves of immaterial being. Hopkins concludes his meditation, noting that the musical "score" of the angels' liturgical hymn determined the nature of the material world (202).[175] Ideally, the angels were "by cooperating [to] create the species and order of the lower world" (202). However, due to Lucifer's "countermusic," the material world "is marked everywhere with the confusion, clashing, and wreck which took place in the higher one" (201, 202).

Unlike the Great Sacrifice (which Hopkins believes is assuredly true), Hopkins' description of creation as "a concert of music" appears (to me) to be wholly figurative (200). Nevertheless, the point of the metaphor is to show that creation is hierarchically organized, and that the ontological nature of the "lower world" chimes with the state of the higher world. Likewise, Christ's progressive incarnation in the Great Sacrifice reinforces the sequential continuity of material with immaterial being. Instead of viewing the immaterial world as

[175] Like "mark," "score" for Hopkins is a complex pun. In one sense, score signifies a musical score. In another sense, however, score suggests a mark or a wound. Particularly, in the *The Wreck of the Deutschland,* "score" recalls the mark of the stigmata: "but he scores it in scarlet himself on his own bespoken" (173).

completely distinct from the world of matter, Hopkins, in his myths and metaphors of creation, represents matter and im-matter as a lower and higher octave in a musical scale.

Often, soul or spirit is considered to be entirely antithetical to matter. But as we have already seen from the previous discussion of aetherial subtle fluids and Galenic spirits, Enlightenment physiologists considered the soul to be able to communicate its motions to matter though a series of quasi-material mediators of exceeding rarefaction. In the nineteenth century, aether theories revived again, and Hopkins, in conceiving of the contiguity of the material and the immaterial, was not alone.[176] Prominent Victorian physicists, in their models of energy fields and the aether, considered energy to cross between the visible world to the "unseen universe," to borrow the title of P.G. Tait and Balfour Stewart's book. While the unseen substrate (whether aether or energy pure and simple) of the physical universe was at times discussed in a material and even mechanical fashion, at other times it was linked explicitly to metaphysical postulates: to the soul, to the spiritual realm, and to God himself.

Two trends of nineteenth century physics lent to the mixing of material and metaphysical modes. First, aether, motion, and force descended to the Victorians already freighted with metaphysical weight, given their antecedents within Galenic physiology and Enlightenment natural philosophy (see above). Victorian physicists failed to distinguish their physical speculations from this metaphysical prehistory, or else knowingly invoked it within their theories. The result was a physical conception of aether and energy that lent itself easily to metaphysical extension. Second, Victorian physicists developed models of the aether that explained its function in meticulously mechanical and quantitative terms. Instead of stripping the

[176] For a seminal history of the resurgence of aether in the early nineteenth century, see Edmund Whittaker's "The Luminiferous Medium from Bradley to Fresnel" in his *A History of the Theories of Aether and Electricity*, vol. 1. I will shortly discuss some of the more salient aether theories from the middle to late nineteenth century.

aether of its metaphysical connotations, however, the physicists' efforts crystallized the aether as a substance that partook of the material and the metaphysical at once.[177] In effect, the aether, a space simultaneously spiritual and mechanistic, conflated the energies of the physical world with those of the transcendent sphere.

Faraday's force-matter ontology illustrates the persistent resonance of metaphysics within Victorian physics.[178] In "A Speculation Touching Electric Conduction and the Nature of Matter" (1844), Faraday argues that matter, in its most basic or atomic form, consists not of particles but force. Contemporary physical theory postulated the atom as a hard, spherical nucleus surrounded by an atmosphere of force or "powers." This definition to Faraday seemed to make untenable assumptions. Faraday argued that the properties of visible matter are determined not by the hard spherical nuclei but by the atmospheres of force/powers that surround them. If these force atmospheres determine the way atoms combine, then they effectively determine the nature and properties of substances apparent to the senses. Accordingly, while scientific investigators have ample evidence of the existence of the force atmospheres or powers of atoms, they have no

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[177] Physicists of the high Victorian period considered the aether to have the properties of an elastic solid. To investigate the way elastic solids reacted to magnetism, light, heat, and other forms of energy, Victorian investigators often studied crystals. (Like all mundane matter, crystal is elastic in that it is imperfectly rigid.) Crystals were particularly advantageous for study because unlike many solid substances, they transmit light. Accordingly, crystals were used in Victorian physical experiments as analogues of the aether. In this way, Victorian physics "crystallized," quite literally, the aether. Give that the aether conveyed light, electricity, magnetism, and even (in some accounts) life itself, it seems likely that the New Age fascination with crystal in recent years stems from crystal's Victorian association with aether. Such a claim could be substantiated by analyzing the role of crystal in Victorian spiritism. I might add that several prominent physicists (Lodge, particularly, as I shall discuss below), were also important figures in Victorian spiritism.

[178] I do not mean to say that Faraday himself viewed force as metaphysical. Faraday is quite clear that "the force which constitutes [. . .] matter" is material, not metaphysical. Nevertheless, given that aetherial subtle fluids often mediated matter and soul in Galenic physiology and Enlightenment natural philosophy, Faraday's imponderable force-matter was similarly viewed by other Victorians. See my discussion, below, of Hare's response to Faraday.

evidence of the hard nuclei themselves. In Faraday's own words, "To my mind, therefore, the *a* or nucleus vanishes, and the substance consists of the powers or *m*" (141).

Faraday borrows his model of the atom from Boscovich (in this paper at least), and posits the atom as an area of force devoid of any hard material nuclei. These force-atoms combine to produce ponderable matter, the substances that we see, feel, taste, and smell. "Force constitutes [. . .] matter," then, and at base, matter is not particulate or ponderable but imponderable (143). Force is the substrate of all material existence.

For Faraday, force exists much as an object or a thing does. Not only does force exist, but at base, all particulate matter (all objects or things) exist as force. Such a conception of force animates Faraday's article "The Conservation of Force" (first published 1857). In this article, Faraday investigates the relationship of gravity with the law of the conservation of energy, or the conservation of "force" as Faraday terms it.[179] According to Faraday, saying that gravitational force decreases between two objects as distance increases between them constitutes a violation of the law of conservation. For most speakers, who view force as a property of matter, such a statement poses no problem. Most people assume that the gravitational energy of the object itself remains the same, but the force or effect of gravity decreases with distance. But for Faraday, force exists independently of objects (and indeed, objects exist dependently on force). From this perspective, force cannot increase or decrease, no matter the relations obtaining between objects. If force exists in the same way that objects or things exist (or, as Faraday might say, in an even

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[179] As mentioned in chapter 1, energy/force was a shibboleth marking affinity for either the North British School or the X Club. Faraday, religiously sympathetic to the North British School but personally sympathetic to his friend and Royal Society colleague John Tyndall, refused to be caught in the middle. When the young James Clerk Maxwell urged Faraday to adopt "energy" instead of "force," Faraday demurred, rejecting the curtailed North British definition of force as the "tendency of a body to pass from one place to another" ("Conservation" 379). Instead, Faraday accorded force a more universal definition, as "the cause of a physical action; the source or sources of all possible changes amongst the particles or materials of the universe."

more real way than they do), then it cannot increase or diminish dependent on relations of matter.[180]

Ostensibly, Faraday has no metaphysical intentions when he delineates his theory of force. For Faraday, not only does force cause or condition ponderable matter, but force itself is matter. Force may lack definite volume, shape, and mass, but the fact that it is nevertheless material appears in Faraday's description of the force-atom. In describing the behavior and nature of the force-atom, Faraday refers to it quite simply as "matter":

> The view now stated of the constitution of matter would seem to involve necessarily the conclusion that matter fills all space, or, at least, all space to which gravity extends [. . .]; for gravity is a property of matter dependent on a certain force, and it is this force which constitutes the matter. In that view matter is not merely mutually penetrable, but each [force-]atom extends, so to say, throughout the whole of the solar system, yet always retaining its own centre of force. This, at first sight, seems to fall in very harmoniously [. . .] with the old adage, 'matter cannot act where it is not' ("A Speculation" 143)

In this passage, Faraday describes the extent and inter-penetrability of force-atoms. If an atom consists of force, then it is present wherever its force is. Gravity is an aspect of the atom's

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[180] Faraday astutely observes that the force of gravity between two objects of definite mass remains constant no matter how many other objects or how much other mass is also attracted. If gravitational force resides within an object, its force must be finite. Thus, it is capable only of a given total force, a force that will be distributed among the mass it attracts. The more mass an object attracts, the weaker its attraction will be on a given unit of that mass. However, gravity in reality acts differently, and attracts a given unit of mass with a constant force, no matter how much total mass there may be. Accordingly, Faraday asserts, the force of gravity cannot reside within objects.

Faraday's challenge went unanswered until Einstein developed his theory of gravity. Incidentally, Faraday's theory that force exists objectively may also be right. According to one modern model (the Standard Model), energy exists as particles – bosuns, leptons, gluons, quarks, and photons.

force; therefore the atom extends as far as its gravitational pull does. Accordingly, every atom fills the solar system, to the extreme reach of its gravitational attraction. Force-atoms are necessarily inter-penetrable then, and combine and merge together within the same space. Each point of space contains an admixture of various forces or force-atoms, and particulate matter evolves from the admixture. The combined disposition of the forces within a given space determines the nature of the particulate matter that occupies that space.

In Faraday's account, force is matter in a sense, but not in the sense usually meant by the word. Victorian physicists who subscribed to Faraday's notion of material force typically referred to it as "imponderable matter" (Hare 248). Moreover, despite Faraday's and his contemporaries' ostensible intentions to treat force as purely physical, their choice of the word "imponderable" links their discussion of force to the subtle fluids of Enlightenment natural philosophy and Galenic physiology. For example, in Thomas Browne's *Pseudodaxia Epidemia, Or, Enquiries into Very Many Received Tenants, and Commonly Presumed Truths* (first published 1646), Browne investigates the efficacy of gold, if swallowed, to alleviate digestive ailments. Browne first observes that the digestive process does not affect the gold's weight. No sensible proportion of the gold is dissolved, then, but Browne reasons that the gold might give off salutary "emanations" or "effluvium" or "subtleties" (95). Browne concludes by reasoning that if therapeutic amulets "do work by emanations from their bodies," and "produce visible and real effects by imponderous and invisible emissions," then gold might do the same (95). In Browne's discussion, the term "imponderous" appears in concert with other terms characteristic of Galenic physiology – emanations, effluvium, subtleties, emissions, virtues, and effluencies. If Victorian physicists intended to distance their hypotheses of force from metaphysical speculation, their choice of the word "imponderable" was unfortunate. Instead of implying a form of matter entirely devoid of metaphysical extension, the phrase "imponderable matter" recalls the role of subtle fluids, spirits, and aethers that mediate soul and gross matter.

Accordingly, while Faraday himself might treat force as a purely material substrate of ponderable matter, the concept of "imponderable matter" (to say nothing of "force" or "power") was already laden with metaphysical import.[181] That such import persisted into the nineteenth century appears in Thomas Young's Royal Institution Lecture XLIX, published 1807. In this lecture, Young constructs a grand scale of substance leading upward from solids to liquids to gases; then to electricity, magnetism, and ether; then to gravitation; and finally to "existences absolutely immaterial and spiritual" (610):

> Nor is there any thing in the unprejudiced study of physical philosophy that can induce us to doubt the existence of immaterial substances; on the contrary we see analogies that lead us almost directly to such an opinion. [. . .] We see forms of matter differing in subtility and mobility, under the names of solids, liquids, and gases; above these are the semimaterial existences which produce the phenomena of electricity and magnetism, and either caloric or a universal ether; higher still perhaps are the causes of gravitation, and the immediate agents in attractions of all kinds, which exhibit some phenomena apparently still more remote from all that is compatible with material bodies; and of these different orders of beings the more refined and immaterial appear to pervade freely the grosser. It seems therefore natural to believe that the analogy may be continued still further until it

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[181] But see David Gooding's "Metaphysics vs. Measurement: The Conversion and Conservation of Force in Faraday's Physics." Gooding argues that "the close link between theology and physics constrained the development of Faraday's concept of force" (2). While I treat Faraday's force as purely material, Gooding makes the case that Faraday's "defenses of the ontological primacy of force" were religiously motivated.

> rises into existences absolutely immaterial and spiritual. We know not but that thousands of spiritual worlds may exist unseen for ever by human eyes; nor have we any reason to suppose that even the presence of matter in a given spot necessarily excludes these existences from it.

Young's nineteenth century "analogy" that enabled him to set solids, liquids, and gases on a continuous scale with "existences absolutely immaterial and spiritual" was the same analogy that enabled Newton in the seventeenth century to associate the body with the "aetherial animal spirit" and the soul. Despite Faraday's ostensible intentions, then, it was possible for readers within and without the scientific professions to consider his imponderable matter of force in light of its historical predecessors in Enlightenment natural philosophy and Galenic physiology. Specifically, many readers perceived force and imponderable matter as a liminal state linking the physical and the metaphysical worlds.

Before examining the ways contemporary readers interpreted imponderable force, I would first like to describe another proposed substrate of matter, the vortex atom as conceived by William Thomson. Like Faraday, Thomson ostensibly distanced his vortex atom from metaphysics, and treated it in purely physical and mechanical terms. As we shall see, however, despite Thomson's empirical treatment, his vortex atom came freighted with metaphysical force already. Because Thomson posited his vortex atom as an unseen substrate of visible matter, contemporary readers (even eminent scientists who worked closely with Thomson!) regarded it as a potentially metaphysical postulate. Together, Faraday's force and Thomson's vortex atom suggest the difficulty with which physical hypotheses in Victorian science were distinguished from their physically metaphysical forebears in natural philosophy and physiology.[182]

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[182] I should repeat, however, that although I take Faraday's force and Thomson's vortex atom at

Thomson outlines his vortex atom in an 1867 article, "On Vortex Atoms." In the article, Thomson credits Hermann Helmholtz's research of frictionless fluids with his own conception of the vortex atom. As Thomson, following Helmholtz, reasons, if a vortex were created in "a fluid perfectly destitute of viscosity (or fluid friction)," that vortex would whirl without end (94). Since the fluid contains no viscosity, nothing physical can catch it to stop its rotation. In fact, "to generate or to destroy [vortices] in a perfect fluid can only be an act of creative power" (94).

But what sort of fluid is "perfectly destitute of viscosity," and what sort of "creative power" can solely and singly act upon this perfect fluid? The answers to these questions show the debt Victorian physics owes to previous centuries of natural philosophy and Galenic physiology. Thomson's "perfect fluid" is an aether that fills the cosmos. Like its counterparts in previous centuries, specifically in the theories of Newton or Galenic physiology, Thomson's aether is a perfectly "subtle" fluid in that it is unapparent to the senses, devoid of any appreciable weight, impervious to compression, and free from all friction or viscosity. Likewise, the "creative power" that alone can interact with aether to produce eternal whirls and vortices is that of none other than God himself.

In speculating about whirls and vortices in a perfectly fluid aether, Thomson, like Faraday, broaches a new version of the atomic theory. Instead of atoms consisting of force, however, Thomson's atoms consist of aether, or more precisely, of vortices within the aether.

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face value as purely physical, I am perhaps naïve to do so. A number of authors have interrogated the theological and metaphysical implications of their speculations. Pertaining specifically to Faraday's force, see David Gooding's "Metaphysics versus Measurement: The Conversion and Conservation of Force in Faraday's Physics," as well as Geoffrey Cantor's *Michael Faraday: Sandemanian and Scientist* and Ian H. Hutchison's "The Genius and Faith of Faraday and Maxwell." Cantor and Hutchison provide a slightly different perspective than Gooding, observing the ways that Faraday's faith contributed to his attitudes about scientific experiment and his relationship with other scientists. However, Cantor and Hutchison avoid making any metaphysical interpretation of Faraday's force itself.

The perfectly frictionless nature of Thomson's aether is critical: In order to explain how atoms persist without alteration, decomposition, or change, Thomson's vortices must be eternally stable.

By Thomson's theory, then, matter does not exist as matter at base. Rather, each atom consists as a perpetual rotation within the aether. If one could perceive as God does, one would not see matter but innumerable vortices spinning in the fluid medium of the aether. These vortices might bump into each other, interact, and briefly merge, but their individual rotary movement would not be altered or impaired by the contact.

Once more, Thomson intends his vortex atom theory to be understood physically. Admittedly, in the opening page of his article, Thomson alludes to God's "creative power," and consequently his explanation rests upon metaphysical assumptions, particularly upon God's agency in stirring the aetherial fluid to generate the myriad vortices within it. Nevertheless, this speculation past, Thomson's discourse proceeds as a physical theory of matter. For Thomson, the aether exists materially, and is responsible for the energetic relations between material particles, as well as for – speculatively -- the existence of these material particles themselves.[183] Other than to God, Thomson makes no reference to any spirit or soul or metaphysical substance.

Such is not the case, however, with Thomson's colleague Balfour Stewart, nor with Thomson's frequent co-author, collaborator, and friend Peter Guthrie (P.G.) Tait. According to P.M. Heimann, Thomson and the majority of scientific notables during the Victorian era

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[183] Thomson was typically guarded in presenting his vortex theory, and characteristically hedged his claims. In his first essay on the subject, for instance, Thomson defends his theory by observing that "it is as easy (and as improbable – not more so) to assume" a vortex atom in aether as it is to assume a "solid indivisible" atom (94). As this remark suggests, Thomson viewed all atomic theories as "improbable." For Thomson, at least in 1867, the one thing that atoms had in their favor was that matter exists. Otherwise, Thomson viewed atomic theories skeptically.

(Heimann mentions John Tyndall, James Clerk Maxwell, and Baden Powell, but he might have included Faraday as well) considered natural history, post-creation, to have progressed apart from divine intervention.[184] Thus, the workings and energies of nature were of one order, and the work and power of God was of another order entirely. Yet Heimann distinguishes Tait and Stewart from their contemporaries. Heimann observes that in their book *Unseen Universe,* Stewart and Tait "argu[ed] that the natural order included an invisible realm which was in communication with the visible universe, [and] explained the manifestations of divine providence in terms of the transfer of energy from the invisible to the visible realm" (75-6). Slightly restated, "Stewart and Tait regarded the operations of divine providence as occurring within the natural order and they sought to relate the manifestations of divine providence to the operation of natural laws" (76).

In *Unseen Universe* (1875), Tait and Stewart set out to justify the ways of God to Victorian science. Opposed to Thomson and Maxwell, who viewed the creation (or annihilation) of matter and energy to be the distinct prerogative of God, and impossible in the natural world apart from the divine will, Tait and Stewart argue that continuity characterizes all of God's actions toward his creatures. Consequently, the act of creation cannot oppose the normal operations of nature. In Stewart and Tait's words, "The power of Divine Being is surely unlimited, but, nevertheless, we have perfect trust that God will work in such a way as not to put us to permanent confusion" (62). In creating, then, God abides by his own laws. These laws

[184] At first sight, Heimann's grouping of Tyndall with Thomson and Maxwell may seem odd. Tyndall was a naturalist in the modern sense of the word, and denied that God had anything to do with the universe's existence. Thomson and Maxwell, contrarily, were devout Christians and revered God as Creator. However, Heimann points out that while Thomson and Maxwell believed that God had created the world, they took creation to stand outside of nature and in opposition to its normal workings. Consequently, creation stands outside of science as well. Practically, then, science for Maxwell and Thomson was a naturalist enterprise in that it studied the relations of matter and energy exclusive of creation and other divine acts.

appear in nature in the relations of matter and energy. If these relations instantiate God's laws, and if God, as a lawful being, acts in accord with his own laws, then the act of creation must be of a piece with the behavior of matter and energy in nature since creation. Creation cannot be discontinuous with nature. For Tait and Stewart, such a claim impugns the lawful nature of God.

Effectively, Tait and Stewart deny the doctrine of creation *ex nihilo*, and replace it with the laws of thermodynamics. If the relations of matter and energy iterate the laws that God set for himself, then thermodynamics is not merely a scientific theory but a divine decree. According to the divine decree articulated as the first law of thermodynamics, nothing comes from nothing.[185] If God acted in accord with his own decree in forming the world, then creation cannot have come from nothing, either. As Stewart and Tait reason, "if the visible universe is all that exists, then the first abrupt manifestation of it is [. . .] truly a break in continuity" (64). Given their reverence for lawful continuity, such a break they cannot allow.

Yet if the visible world cannot have arisen from nothing, from whence did it arise?[186] Stewart and Tait's answer to this question is implied in their caveat "if the visible universe is all that exists." For Tait and Stewart, the visible universe coalesces from an antecedent invisible universe, the aether. This invisible universe produces the visible through an inexorable process, in perfect conformity with the physical laws that God has decreed. The laws of God, then,

[185] My formulation "nothing comes from nothing" perhaps recalls the *Sound of Music* instead of the laws of thermodynamics. To be more precise, then, the first law of thermodynamics as first articulated by Rudolf Clausius in 1850 states that "In all cases where work is produced by heat, a quantity of heat proportional to the work done is expended; and inversely, by the expenditure of a like quantity of work, the same amount of heat may be produced" (4). Effectively, Clausius was saying that a given amount of heat energy translates to an equivalent amount of mechanical energy, but the total amount of energy remains constant. Energy is neither created nor destroyed, then. Nothing comes from nothing, and nothing turns to nothing.
[186] Apparently, they dismiss the possibility that matter could have existed eternally.

articulated by human beings as the laws of energy and thermodynamics, govern both the visible and invisible worlds.

To explain the mechanics by which the invisible world produces the physical, Tait and Stewart invoke Thomson's vortex atom. Thus, an atom of matter is not a hard particle but a stable whirl within the fluid aether. However, Tait and Stewart object to Thomson's claim that the aether is a perfect fluid. If the aether were a perfect fluid, then nothing in nature could set it in motion. Inducing the rotary whirl of an atomic vortex would require "an act impressed upon the universe from without [i.e., by God], and [. . .] must therefore have denoted a breach of continuity" (117). Consequently, Stewart and Tait modify Thomson's theory by envisioning aether as a nearly perfect fluid. As a nearly-perfect fluid, the aether is not immune to physical cause and effect, and atomic vortices may be engendered in the course of nature by physical processes. In its "manifestation," then, the visible world coalesces from the invisible in strict accord with the natural processes decreed by God.

As a nearly-perfect fluid, the aether is still very stable, and the vortical rotations of atoms within it will persist "it may be for billions of years" (118). However, as an imperfect fluid, the aether experiences friction, and its vortices perpetually slow and approach collapse. At some point, they will fail altogether, and when this happens, the visible universe of matter will return to the invisible aether from which it developed.

At first sight, such a catastrophe signals the extinction of material existence, particularly of life. Once more, however, Stewart and Tait invoke aether science to justify the ways of God to Victorian science. Much as the doctrine of creation can be explained by (or at least altered to fit) aether theory, so can the doctrine of the afterlife. For Tait and Stewart, the aether preserves material existence in two ways, both as a historical record of it and as a reservoir of its essential energies. Moreover, if the life-principle or the soul of material beings consists of energy, then the aether conserves it as well. In the aether, the energetic souls of material beings find their eternal abode.

Stewart and Tait's discussion of the aetherial afterlife begins with the proposition that "this medium – this aether – has the power of transmitting motion from one part of the universe to another" (156). By "motion," Stewart and Tait mean "energy." According to the strand of energy physics favored by the North British School through the 1870s, whatever light, electricity, and magnetism may or may not be in and of themselves, they invariably express themselves as motions in aether. Light was typically described as a compression wave within the aether, and magnetism and electricity were accounted for as either rotary or linear movements of aether particles.[187]

Thus aether conveys energy (or the motion associated with energy) through space. For the Victorians, a primary function of the aether was to transfer energy from the sun to the earth. But aether conveys energy in all directions: each incident in the material world is like an epicenter of an earthquake, and the aether transports the energy released by that incident outward through space with astonishing rapidity.[188] In describing the sun's expenditure of energy, for example, Tait and Stewart write that

[187] See my discussion of Maxwell's model of the aether, below. Maxwell's model was one of many, but it aptly illustrates energy's association with moving particles of aether. For the North British School generally, energy existed, for all appearances, as a relation of matter. In this way, the North British differed from Faraday, who viewed matter as a relation of force.
[188] Science owes the terms "electromagnetic energy" and "electromagnetic field" to the nineteenth century. According to the OED, the word "electromagnetic" was first used in an 1820 edition of the *Annals of Philosophy*. "Electromagnetic energy" followed in 1834, in P.M. Cunningham's *Motions of the Earth and the Heavenly Bodies*. Finally, "electromagnetic field" appeared in 1864, in James Clerk Maxwell's Royal Society paper "A Dynamical Theory of the Electromagnetic Field."

> All but a very small portion of the sun's heat goes day by day into what we call empty space, and it is only this very small remainder that is made use of by the various planets for purposes of their own. Can anything be more perplexing than this seemingly frightful expenditure of the very life and essence of the system? That this vast store of high-class energy should be doing nothing but traveling outwards in space at the rate of 188,000 miles per second is hardly conceivable, especially when the result of it is the inevitable destruction of the visible universe. (155-6)

Such waste, for Tait and Stewart and Victorians in general, was "inconceivable." Subsequently, however, Tait and Stewart reclaim the prodigal expenditure. In propagating energy outwards, the aether preserves a memory (Tait and Stewart use the word "photograph") of each event in the material world. Since aether conveys light and energy throughout the universe, every event is reenacted at every moment in some place in the universe.[189] If one could travel fast enough to keep pace with the lightspeed motions of aether, one could see and experience the event in still-frame as its energetic "photograph" sped out into space (156).[190]

Thus, the "astounding phenomenon" of energy expenditure "may only be an arrangement in virtue of which our universe keeps up a memory of the past as well as the present" (156). Ultimately, energy expenditure is "historically" justified – justified in composing a history of the visible world. But in addition to justifying energy's expenditure, the aether also recoups it. When

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[189] To be more precise, every event is reenacted at every moment in a thin but ever-enlarging shell or sphere.

[190] For instance, the light of the sun takes approximately 8 minutes to reach earth. When we look at the sun, then, we are not seeing the sun as it is at the present. Instead, we are seeing the sun as it existed 8 minutes ago. The light energy travelling outward from the sun preserves a "memory" or "photograph" of the sun. If we could travel far enough away, we would be able to see the sun as it existed any number of years ago.

energy radiates out into space, it may disappear for a short while from the visible world, but it is conserved within the aether. Accordingly, when energy enters the aether, it is not lost but is merely “transferred” from the visible world “into an invisible order of things” (158).[191] Stewart and Tait inquire, “May we not at once say that when energy is carried from matter into ether it is carried from the visible into the invisible; and that when it is carried from ether to matter it is carried from the invisible into the visible?” (159). For Tait and Stewart, this is a comforting thought. Should the atomic vortices of matter ever cease to whirl, and should the visible world vanish altogether, the energies of the defunct world will enter the aether where they will be perpetually conserved.

But the consolation of aether applies personally as well as universally. At various points, Stewart and Tait consider thought in energetic terms. In one instance, Tait and Stewart remark the disparate intensity of thought energy in the brain versus motor energy in the muscles. They observe that “a very small and obscure transmutation of energy in the mysterious brain chamber may determine some very violent motion” (146). Thought and muscular movement are both energies then, and the miniscule energy of electricity in the brain that prompts the explosive burst of muscular work is much like the spark that ignites gunpowder or the “slight tap [that causes] the explosion of a large quantity of fulminating silver” (146).

The pair elaborate their idea in a later passage, reasoning that if energy passes from the physical world to the unseen universe, so the energies of thought may pass from the physical body into the spiritual body:

[191] Stewart and Tait equivocate whether aether is a bridge between the visible and invisible worlds, a container or “medium” of the invisible world, or the substance of the invisible world itself. See 158-9. Notwithstanding, whether aether is bridge or container or substance, when energy leaves the visible world and enters the aether, it likewise enters the unseen universe.

> Now each thought that we think, is accompanied by certain molecular motions and displacements in the brain, and part of these, let us allow, are in some way stored up in that organ, so as to produce what may be termed our material or physical memory.[192] Other parts of these motions are, however, communicated to the spiritual or invisible body, and are there stored up, forming a memory which may be made use of when that body is free to exercise its functions. (159).

As energies in nature transition back and forth between apparent matter and the unapparent aether, so the energies of thought reciprocate between the physical body and the "invisible" or "spiritual" body (159). That this invisible body corresponds to the invisible universe appears later, when Tait and Stewart entertain the problem how individuality "will be preserved in the spiritual world" (164). To answer this difficulty, Tait and Stewart reason that if the physical brain can retain one memory distinct and whole from among millions of others, so the "universe of the future" can retain the energies of one person's memories whole and distinct from those of other persons' (164). From this, it appears that invisible bodies stand to each other in the aetherial medium of the unseen world much as memories stand to each other in the medullary substance of the brain. Just as a memory is a local arrangement of energy and matter within the substance of the brain, so the invisible or spiritual body is a local arrangement of energy and aether within the substance of the unseen universe. In both spheres, however, grossly material or aetherial, memories are energies contained within substance. In the physical body, the brain's substance preserves energetic memories; in the spiritual or aetherial body, the invisible body's substance preserves energetic memories. Much as memories generate identity and self-

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[192] Observe the similarity of Tait and Stewart's "material or physical memory" and Hopkins' "scape." For Stewart, Tait, and Hopkins, scapes/material memories are physical stores of energy (electricity) within organic matter.

coherence in physical life, so memories extend and preserve identity in the afterlife of the unseen world.

Though farfetched by twenty-first century sensibilities, *Unseen Universe* illustrates the ambiguous status of aether and energy in Victorian speculation, popular and scientific alike. Because of their uncertain ontology, aether and energy were often considered by Victorians to be in some way analogous with the soul, or with metaphysical existence generally. Admittedly, Stewart and Tait repeatedly claim to proceed from purely scientific principles and to eschew metaphysical uncertainties.[193] And to be fair, they depict spiritual bodies and the aether as material, albeit matter of an imponderable sort. As Tait and Stewart explain, in contradistinction to the typical division between material and immaterial substance, "we substitute for *matter* the words *gross matter*, and for *immaterial* the words *not grossly material*" (161, italics original to text). Effectively, Tait and Stewart extend the empire of the physical into regions traditionally considered metaphysical.

Tait's and Stewart's protestations aside, it is difficult to distinguish the spirit and the afterlife from metaphysics. Such topics are metaphysical by long tradition. Moreover, given that imponderable substances mediated matter and im-matter from the seventeenth century through the nineteenth, (e.g. Newton's physics, Galenic physiology, and Young's ontology), positing the existence of matter "not grossly material" seems to be a metaphysical strategy by default. Essentially, the strategy involves transposition, and shifts the soul's substance from strict immateriality to imponderability (or to "not grossly material" matter). While such a strategy allows for the soul's substance to be interrogated physically, it nevertheless preserves the

[193] See pg. 73: "We do not here intend to enter any metaphysical speculation." See also pg. 102: "But his attempted proofs are for the most part absurd, based, as they generally are, upon mere metaphysical speculations and altogether preposterous analogies."

characteristically metaphysical distinction between mundane and super-mundane substance. Accordingly, such a strategy brings the physical and the metaphysical in close proximity. But to claim that it avoids the metaphysical entirely is tenable only by positing a narrow definition of metaphysics.[194]

Not all Victorians approved Tait and Stewart's speculation. Particularly, James Clerk Maxwell and William Thomson regarded *Unseen Universe* with bemused incredulity.[195] Nevertheless, Tait and Stewart were anything but cranks, and twenty-first century readers should beware dismissing their theories as scientifically uniformed or culturally unimportant. The book went through nine editions in the first five years following initial publication. Moreover, Tait and Stewart were eminent physicists in their time. Tait graduated from Cambridge as Senior Wrangler, and was Professor of Natural Philosophy at the University of Edinburgh from 1860 until shortly before his death in 1901. As a mathematician and a physicist, Tait collaborated with William Rowan Hamilton to develop quaternion mathematics, essential to Einstein's theory of relativity. With Thomson, Tait collaborated theoretically and experimentally throughout his career, and coauthored the *Treatise on Natural Philosophy,* a seminal work in the history of physics. Thanks to his theoretical investigations of vortex-filament knots (see below), Tait's reputation is currently rising again, and he has been cited as an influential figure in knot theory.

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[194] Etymologically, "metaphysics" means "beyond physics." Thus any subject that can be considered physically or scientifically can be regarded as non-metaphysical. But as with so many other words, the conventional meaning of the term "metaphysical" has shifted from its etymological roots. Traditionally, the soul and the afterlife have been metaphysical postulates. Translating these postulates from immateriality to quasi-materiality does not purge their metaphysical associations. It merely punctures the membrane between physics and metaphysics, or advances physics into traditionally metaphysical territory.

[195] William Thomson's biographer, Silvanus P. Thompson, writes that "Sir William Thomson did not like [Tait and Stewart's] book" (1.480). Maxwell's bemusement appears in his poem "My Soul's an Amphicheiral Knot." Maxwell wrote a less whimsical response for *Nature* in his review of *Paradoxical Philosophy*. *A Sequel to Unseen Universe*.

The Tait Chair at the University of Edinburgh was established in 1922 (Max Born was the second incumbent), and Peter Higgs was a lecturer at the Tait Institute (founded 1955) when he wrote his theoretical predictions about the Higgs Bosun.[196]

Nor were Tait and Stewart alone in their speculations. Other Victorian scientists entertained similarly metaphysical estimations of aether or matter. Notoriously, Sir Oliver Lodge endorsed a similar rapprochement of Christian metaphysics with Victorian aether science. Like Stewart and Tait, "Lodge's scientific work [. . .] convinced him that the ether was the medium that unified the whole of nature," a whole that comprised the mundane and the metaphysical at once (Bowler 49). As Peter Bowler explains, Lodge "became committed to the idea of a spirit world on the [a]ethereal plane," particularly after his son Raymond's death in World War I (49). Once more resembling Stewart and Tait, Lodge equated spirit with aether, and regarded the resurrected bodies of Christ and the blessed to consist of aether.

While Faraday's, Thomson's, Tait and Stewart's, and Lodge's conceptions of the material substrate differ, what unites them is that each sought to understand physically a domain that had traditionally been understood metaphysically. Each of these figures claims that his speculation extends from physical research, and that the unseen world may be apprehended in strictly physical terms. Such rhetoric is necessary in order for these physicists to distinguish their speculations from metaphysical postulates. These distinctions may hold logically, but only if one takes at face value the physicists' various redefinitions of terms and disciplinary domains. Thus, for Faraday and Thomson, one must sever imponderable matter from its traditional associations with subtle fluids that mediate soul and body. Likewise, for Stewart, Tait, and Lodge, one must

[196] Stewart was also a highly regarded physicist. He was the director of Kew Observatory, and professor of physics at Manchester University. He is best remembered for positing the link between sunspots and magnetic storms.

redefine spirit in purely energetic and material terms, and locate the afterlife within the domain of physical science.

What distinguishes these figures, however, is the extent to which physics encroaches upon metaphysics. Faraday and Thomson extend physics to include imponderable matter, but they preserve God, the soul, and the act of creation as entirely distinct from physical processes. While Faraday and Thomson stretch the seams of the physical world, they maintain a hard and fast distinction between matter and metaphysics. Contrarily, Tait and Stewart, urged by their commitment to Continuity, push physics much further into traditionally metaphysical territory. They treat the soul or spiritual body as material, albeit "not grossly" so (161). Likewise, arguing that "it is the duty of the man of science to push back the Great First Cause in time as far as possible," they maintain that the visible world "develops" from the unseen universe of aether by natural processes (65).[197] In effect, then, Tait and Stewart bring the physical and the metaphysical into nearly perfect overlap. Compared to Faraday and Thomson, who expand the purview of matter but nevertheless preserve distinctions between physics and metaphysics, Tait and Stewart collapse the two into one. Existence for Tait and Stewart is univocal, and the categories of physics and metaphysics are tautologies.[198]

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[197] Tait and Stewart's preference of "development" instead of "creation" is telling. Given the doctrine of creation ex nihilo, the term "creation" implies that the world was made from nothing. Such an implication constitutes a sharp break in continuity. Contrarily, "development" implies a natural process working continuously over time.

[198] I have limited myself to Stewart and Tait's speculations concerning aether, but the pair actually push the continuity of physics and metaphysics much further. Tait and Stewart conceive of the Universe as an endless series of concentric spheres. The innermost sphere is the visible universe. It is generated by the next sphere, an aether, which despite it comparative refinement is next to the physical universe in gross materiality. This aether, in turn, is generated by a still more refined sphere of aether, which is generated by a yet finer sphere. So on and so forth through infinite regressions, infinite because God himself is infinite. The ultimate sphere of being is Jesus the incarnate word, who has "in some mysterious sense [. . .] submit[ted] to conditions and [. . .] enter[ed] into the universe" (174). Thus the continuity of physics and metaphysics leads all the

Along with James Clerk Maxwell, Thomson, Tait, Stewart, and Lodge indicate the boundaries of aether physics in the Victorian era. Thomson speculatively posits aether as a physical substrate. Tait, Stewart, and Lodge extend Thomson's speculation, regarding aether as the substrate of the visible world and the invisible universe alike. Finally, Maxwell (see below) treats aether not as a material substrate but merely as a refined form of matter capable of conveying the energies of light, electricity, and magnetism. Taken together, these various formulations indicate the range with which Victorians regarded the aether. Indisputably material, uncertainly yet potentially more than material, the aether enrolled hard science and religious hope, often within the same individual.

5.6 Cogwheels and Idle Gears: Material Models of the Aether

With this range in mind, I will briefly sketch several models of aether. It should be remembered that aether in the late Victorian era was susceptible to both physical analysis and metaphysical extension. Although physicists might ply the aether with complex mathematics and excruciatingly mechanical analogies, their rigorous calculations do not prohibit more lively speculation, and often (in the case of Tait and Lodge particularly) mask the physicist's own metaphysical philosophies. Such models of aether brought the metaphysical and the physical into close proximity, and illustrated the universal action of energy within and beyond physics.

Drawing from Helmholtz's and Thomson's aether vortex theory, P.G. Tait set out to classify the various forms a vortex could take.[199] Instead of wide and shallow, like an eddy in a

way to Jesus, the second person of the trinity. Only God the Father, the "unapproachable Creator," exists entirely beyond physics (174). In fine, Tait and Stewart's *Unseen Universe* is a scientific romance similar to Hopkins' theological romance of the Great Sacrifice. For Tait and Stewart and for Hopkins, Jesus is a hero on quest to glorify God, who forms the cosmos (seen and unseen) as a direct result of his incarnation.

[199] To be clear, Tait's knot theory is not a scientific model. Scientific models 1) offer physically causal explanations of observed events, 2) make predictions that are testable, and 3) analyze

creek, Thomson's aether vortices were narrow and deep like a tornado. Just as a tornado's shaft of whirling air rises miles above the ground, causing the tornado to appear thin and thread-like from a distance, so the vortices of Thomson's and Tait's theory took the form of long, thin threads of whirling aether particles. But unlike a tornado and more like a length of sewing thread, Thomson and Tait's vortex thread could loop back on itself and knot, forming a "vortex ring" or a vortical knot ("Recent Advances" 297). As Tait and Thomson conjectured, if atoms are vortical knots of aether, then each different kind of knot forms a different atom or element of matter.

Accordingly, Tait set himself to classify the various knots. In so doing, Tait was not merely embarking on a tedious mathematical exercise. Instead, Tait thought he was "constructing a periodic table of elements" (Stoimenow 285). Assuming that the atoms of matter are knots of vortex threads, and assuming that the aether contains every form of knot possible, then each knot represents an element of matter.[200] Tait assiduously classified "the first seven orders of

phenomena mathematically to enable additional predictions. Tait's theory lacks these attributes. Because Tait does not explain how the aether vortices developed, his theory lacks causal explanation. Likewise, because Tait's predictions apply to future events (the afterlife, the end of the world), testing them in the present is difficult. Finally, while Tait describes his knots geometrically, he did not elaborate his theory sufficiently to enable scientists to predict the number and nature of knots at higher order knottiness. In this, I do not mean to accuse Tait, an accomplished mathematician, of shoddiness. Scientific theories typically lack a model in their first inception. Furthermore, knot theory is still developing, and has only recently developed the mathematical apparatus necessary to make reliable predictions. Instead, I merely mean to distinguish Tait's theory from a true scientific model. Nevertheless, I discuss Tait's theory alongside Maxwell's and Lodge's models in order to point out several salient traits. Namely, that Tait takes a decidedly material view of the aether, but nevertheless imbues it with metaphysical properties.

[200] Tait apparently believed that the aether (or at least the earth) did not contain all of the possible forms of knots. In his "On Knots," Tait observes that "we now see that the distinctive forms of less than 10-fold knottiness are together more than sufficient (with their perversions, &c.) for the known elements" (321).

knottiness" by himself, before Charles Little and Thomas P. Kirkman largely took over his work ("On Knots" 335).[201]

Tait often remarks upon the labor required to tabulate knots. He appealed to the public for help in the 1884 edition of the *Philosophical Magazine*: "The requisite labour increases with extreme rapidity as the number of crossings is increased [. . . .] It is greatly to be desired that some one, with the requisite leisure, should try to extend this list" (Listing's *Topologie"* 97). Thus knot tabulation proved to be a laborious and mathematically-intensive task. Nevertheless, to set Tait's *Unseen Universe* alongside his work with knots, Tait apparently feels no incongruity in identifying the aether as the locus of laboriously geometrical knots at the same time that he identifies it as the abode of the soul.[202] For Tait, the physicality of the aether does not besmirch its spiritual associations.

The same cannot be said of James Clerk Maxwell, however. Maxwell and Tait were close friends since youth, and "corresponded by the new half-penny postcards almost daily" (Silver 9). One of the poems Maxwell sent Tait pokes fun at the knotty spirituality of Tait's aether:

> My soul's an amphicheiral knot,
>
> Upon a liquid vortex wrought
>
> By Intellect in the Unseen residing
>
> And thine doth like a convict sit,
>
> With marlinespike untwisting it,
>
> Only to find its knottiness abiding;
>
> Since all the tools for its untying

[201] By "knottiness," Tait means the number of times the thread crosses itself to form the knot. Thus, a knot of seventh-order knottiness has seven crossings.

[202] Tait and Stewart composed *Unseen Universe* in 1875. He and Stewart continued to publish editions of the book through the early 1880s during the time when he tabulated knots.

In four-dimensional space are lying. (Knott 242)

Maxwell's poem (written "after Shelley," Maxwell assures his friend) spoofs Tait's aether, conflating Tait's aetherial soul with his aetherial knots. In Tait's actual theory, aether comprises both the soul and atoms of matter, but in different ways. The soul consists of aether pure and simple, while atoms consist of aether-made-matter in the form of vortical knots. In his parody, however, Maxwell confounds soul and atoms, representing the soul as material, as a vortex knot. In so doing, Maxwell intentionally misunderstands Tait's philosophy in order to point up the implausibility of an aether that is simultaneously material and spiritual.

Although Maxwell's model of the aether lacks the spiritual extensions of Tait's theory, it is every bit as material. Instead of knots and whirling vortices, however, Maxwell employs whirling tubes and idle wheels.[203] Moreover, instead of explaining how aether supplies matter, Maxwell attempted to explain how aether propagates light, magnetism, and electricity. By Maxwell's telling, the various forms of electromagnetic energy (light, magnetism, and electricity) do not exist in their own right but as effects of the aether. To be more precise, each form of electromagnetic energy is caused by a specific type of movement of aether particles.[204] A magnetic field is generated by rotary movement of aether particles, an electric current by translatory displacement, and light by contiguous collision of particles (a shockwave).

For Maxwell, magnetism and electricity link particularly closely. Maxwell explains magnetism as the product of vortex tubes whirling furiously. Similar to the Thomson-Tait vortex, Maxwell's vortex tube consists of aether particles in rotary motion. These tubes extend in

[203] Like Lodge, Maxwell actually proposed several differing models of aether. Here, though, I will discuss the model Maxwell proposes in his 1861-2 "On Physical Lines of Force."

[204] The previous two sentences may be debated. Admittedly, energy takes the form of movement of aether particles. Presumably, however, something caused the particles to move. Whether energy is the movement or the cause of movement locates energy ontologically postcedent or antecedent to aether.

parallel lines through a given volume of aether. Apparently, like Tait's aether, Maxwell's aether is imperfectly devoid of friction, for the whiling tubes impart a rotary motion to the entire mass of aether. In this way, the tubes' local rotation generates a field capable of moving grossly material objects.

At this point, however, Maxwell encounters a problem. Maxwell insists that the aether is contiguous, or that each particle is in immediate contact with those around it. Yet if vortex tubes are contiguous, they must rotate in opposite directions. Otherwise, their particles will smash together and bring the tubes' rotation to a halt. As with interlocking gears, if one gear rotates clockwise, the other must rotate counterclockwise. But an arrangement of alternately rotating tubes poses yet another problem. If the vortex tubes rotate in opposite directions, they cannot impart a consistent motion to the larger mass. The motion imparted to the mass by one tube will be cancelled by that imparted by another tube.

Maxwell solves this problem by supposing that vortex tubes are separated by intervening particles. These particles act as idle wheels. Edmund Whittaker explains that in mechanics, "when it is desired that two wheels should revolve in the same sense, an 'idle' wheel is inserted between them so as to be in gear with both" (247). Thus, if a vortex tube rotates counterclockwise, the intervening particle or idle wheel will rotate clockwise, allowing the next vortex tube to rotate counterclockwise. This arrangement pervades the aether, allowing vortex tubes to rotate in the same direction and to impart a uniform motion to the mass of aether.

But the idle wheel particles do not exist purely for the sake of saving the model. Rather "these particles [are] 'electricity'" as Maxwell writes Thomson in a December 10, 1861 letter (*Scientific Letters* 692). When the field of tubes and idle wheels is at equilibrium, these electrical idle wheel particles rotate in unison with the tubes, spinning in place but remaining still otherwise. However, when for some reason a tube begins to rotate more rapidly than the other tubes, the entire system, interlocked so tightly as it is, experiences stress and strain. The faster spinning vortex expands as a result of centrifugal force, shoving its idle wheels outward, which impinge upon the neighboring vortex tubes, which in turn impinge upon their idle wheels, and so on throughout the field. Such moments of stress, in which the particles of the field shift or are displaced, constitute currents of electricity.[205]

While electricity links causally to magnetism in Maxwell's theory, light does not. Light for Maxwell is not generated within or by the aether itself, but is imposed upon it from without by a luminous source of gross matter.[206] Once it enters the aether, light travels through the field as a "propagation of disturbances" (Whittaker 251-2). In other words, light is a shockwave or compression wave in the aether, and is conveyed as a chain reaction of aether particles bumping into one another.

Oliver Lodge, in devising his cogwheel model of aether, adopted Maxwell's model but revised it in several ways. Particularly, Lodge attempted to explain light as arising from the field itself, or as causally linked to electricity and magnetism. To accomplish this, Lodge changed Maxwell's model in several ways. For Maxwell, at least in his 1861-2 papers "On Physical Lines of Force," magnetism was a rotary force, and electricity was a derived translatory force. Lodge

[205] Contrary to modern understandings of electricity, in which electrons move rather freely, Maxwell's electrical particles were closely boxed in by other particles. When they shifted, they did not shift far. Nevertheless, because one particle is in close contiguous contact with another, one particle's shift will rapidly propagate throughout the medium. As such, Maxwell's particles do not shift far individually, but they occasion a rapid shift throughout the entire medium.

[206] Typically, light was considered to be the result of vibrations in gross matter. When the molecules of gross matter were sufficiently excited (whether by a blow, by heat, by chemical action, etc.) they would vibrate rapidly. Since aether surrounds grossly material objects, the molecule, in vibrating, would slam into particles of aether, displacing them and sending them crashing into other particles of aether, setting up a chain reaction. Thus the molecular vibrations of gross matter would be transferred to the aether in the form of radiant light or heat, depending on wavelength.

borrows Maxwell's whirling tubes of aether, but instead of assigning them to magnetism, he assigns them to electricity. Furthermore, Lodge eliminates the intervening idle wheels of Maxwell's model, and brings the whirling tubes into direct contact, much like two interlocking gears or cogwheels. This induces the tubes to rotate alternately in opposite directions, a feature Lodge takes to explain positive and negative electricity. As Bruce J. Hunt describes, "One kind of vortex represented positive electricity and spun in one direction; the other represented negative electricity and spun the opposite way" (Hunt 31). Under the influence of magnetism, the vortex tubes twisted, "wherefore a disturbance would spread laterally [. . .] and hence that light could be got from oscillations" (quoted Hunt 31).

In physical terms, Lodge's model of aether is an adaptation of Maxwell's. Both begin with a parallel arrangement of whirling vortex tubes disposed as interlocking cylindrical gears. From the basic dynamics of these whirling tubes, both derive the behavior of magnetism and electricity, and Lodge additionally derives light. In its meticulously mechanical account of physical causation, Lodge's aether model closely resembles Maxwell's. But unlike Maxwell, Lodge's physical conception of the aether does not prevent him from subsequently annexing a spiritual conception of aetherial bodies in the afterlife. For Lodge, traditionally metaphysical entities like souls and spirits are compatible with the aether and the physical mode of causation that obtains within it. In his alliance of physical causation with metaphysical speculation, Lodge's total construction of aether resembles Tait's as much as it does Maxwell's.

Once more, Maxwell's, Lodge's, and Tait's models suggest the uncertainly spiritual signification of aether in Victorian England. Maxwell, although a devoted member of the Presbyterian Church of Scotland, apparently assigned no religious significance to the aether. In Maxwell's model, the aether is a purely material affair of gear mechanisms, idle wheels, and particles in movement. But while Lodge and Tait do assign religious significance to their aethers, their aethers are every bit as physical as Maxwell's, as are the spiritual bodies that inhabit them. In the aether, the physical and the not-grossly physical meet, and souls or spirit bodies get on comfortably with cogwheels and vortical knots.

With their gears, knots, threads, idle wheels, cogwheels, and vortices, the aforementioned models of aether may sound to twenty-first century ears more like explosions in a tinker's cart than like models of scientific theories. Yet again though, twenty-first century readers should avoid chronological snobbery. First, it should be remembered that models provide a means to wrestle with difficulties. While they posit an imagined reality, they are regarded with varying degrees of certainty, and are accorded full conviction only after trial. Thus, Thomson regarded his theory of vortex atoms hopefully but skeptically. Likewise, Maxwell initially discussed his idle-wheel model as a thought experiment, and offered it as a realistic explanation of aether only later. Second, the purpose of models often is not to represent things as they actually exist, but to approximate relations between things. Whether Lodge actually believed that positive and negative electricity striped the aether in oppositely-ginning tubes is not really the point. Instead, the value of the model is that it gave him a way to represent the properties of electricity visually, and to draw inferences about magnetism and light from the proposed analogy.

Nevertheless, certain propositions appear from Victorian models of aether. Most assuredly, the aether was material, and despite its rarefaction it obeyed the same laws that govern courser matter. Somewhat less assuredly, the rarified physical aether bridged the world of gross matter and the world of not-grossly-material spirit. And finally, depending on the individual's acceptance of the second proposition, a third proposition appears: that the spiritual and physical realms are consonant, ordered by the same laws and relations of matter and energy.

These propositions provide a context from which to consider two perplexing questions that I mentioned earlier concerning Hopkins' model of hell: How can scapes within disembodied souls be material? How can the soul in hell be set "texturally at stress" and "burn" (136, 138)? To these I might add another question in anticipation: How is the soul like a magnet?

Before answering these questions, I should briefly review the highlights of Hopkins' engagement with physical science.[207] At Stonyhurst (1870-2, 1882-4), Hopkins shadowed the internationally-recognized astronomer and meteorologist, Father Stephen Joseph Perry, along with his colleague Walter Sidgreaves. As Tom Zaniello notes, Perry was "Hopkins' friend" and "mentor in matters scientific" ("An Attentive Observer" 326; "Scientific Interests" 511). Moreover, Zaniello writes that Hopkins worked with Perry in the Stonyhurst Observatory, "one of the nation's leading meteorological stations" ("Scientific Interests," 511). As well, periodically before, during, and after Stonyhurst, Hopkins read the scientific journal *Nature*. Four of Hopkins' letters to *Nature* were published between 1883-4. Moreover, in Dublin Hopkins continued to study science. In an 1886 letter to R.W. Dixon, he outlined a plan to write a "popular account of Light and Aether" (139). In this letter, Hopkins picks a bone with P.G. Tait particularly, claiming that Tait simplifies the natural world to "a world of formulas," or to an ideal reality which exists only "in thought" (139). Hopkins, ever a lover of the distinct, individual shapes of nature, was annoyed by Tait's penchant to set aside phenomenal appearances (and the wholistic selves they express) in favor of abstract characteristics.[208]

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[207] For a more complete account, please see the beginning of Chapter 3.

[208] I do not believe that Hopkins objects to Tait's quest to find an underlying truth in matter, or an ultimate substrate of being. Granted, Tait's theory of aether amounts to this, but so does Hopkins' philosophy of divine instress. Rather, I believe Hopkins perceived Tait as a sort of Dickensian Bitzer, a person who identifies a horse as a graminivorous quadruped with forty teeth. In other words, Tait enumerates classifications instead of describing appearances. For Hopkins, phenomenal appearance was a true witness, if viewed rightly, of underlying essence.

Hopkins composed his commentary to Ignatius' "A Meditation on Hell" in the "Long Retreat, and later, 1881" (*Sermons* 138). This date falls after Hopkins' first Stonyhurst residence but before his letter to Dixon (1886) expressly mentioning Tait and the aether. While Hopkins' does not discuss his knowledge of aether prior to 1886, critics typically consider Hopkins to be knowledgeable of basic physical theory post-Stonyhurst, thanks to the influence of Father Perry. Certainly, aether theory was basic to Victorian physical science, particularly to astronomy. Given the fundamental importance of gravity and light for astronomy, and given the essential operation of aether (as understood by Victorian science) in conveying gravity and light through space to stars and planets and satellites, it seems difficult to conceive of Hopkins being ignorant of the aether while being mentored by the "foremost Victorian astronomer" in Father Stephen Perry (Zaniello "An Attentive Observer," 326).

A closer look at Father Perry's scientific achievements illustrates the importance of aether theory to his work. Perry's specialty was "solar and magnetic phenomena," and "his magnetic surveys were standards in the field" ("An Attentive" 327). From the aether models of Maxwell and Lodge, we have already seen the importance of aether for magnetic theory. Likewise, Perry lectured publically on spectroscopy, "with sometimes as many as one thousand in attendance," Zaniello writes ("An Attentive" 327). Spectroscopy is the study of lightwaves. Given that, as Victorians believed, lightwaves could not travel apart from the aether, aether enjoyed nearly axiomatic status in Victorian spectroscopy. Indeed, as Whittaker observes, Young and Fresnel's experimental evidence of lightwaves as opposed to light corpuscles was considered

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Most likely, Hopkins was simultaneously fascinated and repulsed by Tait's philosophy – fascinated by Tait's perception of unapparent essence, but repulsed by the dissociative dissection by which Tait achieves it.

ipso facto evidence of aether (107-27). If there could be no lightwaves without aether, then the presence of lightwaves signals the presence of aether.

In short, Father Perry's work was intimately associated with aether theory, and Hopkins studied under Father Perry for several years. As unlikely as it would be for any scientifically informed Victorian to be ignorant of aether, it would be even more so for Hopkins.[209]

5.7 Instress and Fields of Force: Hopkins' Model of Hell

Hopkins, in his 1881 commentary on Ignatius' "A Meditation on Hell," never mentions aether expressly. However, his mechanical model of hell's stresses and energy fields resembles contemporary physical models of the aether. Moreover, Hopkins' treatment of souls as substantial, and hence subject to physical relations, recalls Victorian speculations about the nature of aether and its correspondence with metaphysical states. Finally, in depicting God's wrath and the human soul as fields of opposed energy, Hopkins links the spiritual and the physical, and shows the operation of energy throughout the total integrated universe. In this commentary, Hopkins constructs a physical model of hell that offers an energetic explanation of the pains of damned souls. Similar to the energy and aether models devised by scientific contemporaries, which set the metaphysical substrate of the universe in material and even mechanical terms, Hopkins' model of hell advances a mechanically causal account of the soul's metaphysical torment.

Daniel Brown, in his *Hopkins Idealism: Philosophy, Physics, Poetry,* observes the action of energetic fields and stresses in Hopkins' hell (269). Building on Brown's analysis, I would like to consider Hopkins' description of hell in light of scientific contemporaries' models of the

[209] Hopkins' poems and papers mention aether and spectroscopy (albeit rarely) even before Stonyhurst. For instance, see Hopkins' Oxford poem "The Rainbow," as well as his essay "The Tests of a Progressive Science." It is likely then that Hopkins was aware of aether theory even while at Oxford. Nevertheless, he almost certainly was after Stonyhurst.

energetic aether. While aether theorists such as Thomson, Maxwell, Tait, Stewart, and Lodge were not certain that they had found the way aether and energy worked precisely, they were confident that energy behaves consistently, whether in aether or in grosser matter. In much the same way, Hopkins' model of hell is speculative, but it does suggest that energy behaves consistently, whether upon souls or upon material bodies. Common to models of aether and Hopkins' model of hell is the belief that energy acts like energy, regardless of the substance upon which it acts.

Accordingly, while Hopkins' model applies to metaphysical entities (souls) within a metaphysical state (hell), it works according to physical laws of causation, or according to the behavior of energy observed in physical objects. Much as Maxwell's idle wheels, Thomson's vortices, Tait's knots, and Lodge's cogwheels expressed the dynamics of energy within the aether as conformable to the dynamics of energy within grossly material bodies, so Hopkins' model expresses the dynamics of hell in terms of the energetic relations of material bodies. If the physical and the metaphysical exist within an integrated universe, then energy's operation within the unseen universe is conformable to its operation within the visible world.

In his history of hell's creation, Hopkins writes that "the stress of God's anger [. . .] first 'prepared' or called into being fire against the Devil and his angels" (*Sermons*, 137). As in his 1880 and 1881 notes, God's force or power or – here – his "stress" calls into actual being what had previously existed only potentially. While hell may be a location, it is primarily a personal state, the condition of an individual suffering "an intensification or terrible instress [of God's anger] upon the substance of one" (137). Hell is God's wrath, instressed.

In this description, Hopkins simultaneously treats Hell, God's instressed wrath, in metaphysical and energetic terms. Metaphysically, hell is a potential state that has been actualized or “called into being” by “the stress of God’s anger” (*Sermons* 137). But energetically, hell is actualized by interposition of physical energy, and the “stress of God’s anger” operates as an energy field. More specifically, Hopkins describes God’s wrath as a magnetic field. Rehearsing the fall of Satan and his angels, Hopkins writes that

> It was an intensification or terrible instress [of God’s anger] upon the substance of one, Satan, first of all, casting that, with straining, in one direction [which is the being cast down to hell) and acting through that, by a subordination or hierarchy (hence “his angels,” missionaries, subalterns), on the rest, so that their obedience is one of slavish fear and necessity. (137)

In effect, God directs his anger against Satan, and through Satan to the rest of the fallen angels. God’s wrath behaves as an electrical current or magnetic field, catching Satan first but passing through him to his followers. Appropriately, Hopkins at this point inserts a half-parenthetical analogy likening the fallen angels to iron shards in a magnetic current: “So, I think, as a magnetic current is heightened needles and shreds of iron rear, stare, and group themselves, *se dressent*, at the poles” (137, italics original to text).[210] Hopkins’ half-parenthesis is ironically appropriate in that the analogy it contains is, once more, more than analogical. The parenthesis purports to compare God’s wrath to a magnetic field, but in effect it suggests that God’s anger *is* a field, if not of magnetism per se then of a divine energy that similarly affects objects.

In the figurative terms of the analogy, several images associate the shreds of iron in the magnetic field with the devils in God’s anger. First, the iron shreds “rear,” and Satan and his angels rise and stand up against God. Second, the iron shreds “stare,” while the Devil and his

[210] I call the present sentence a half-parenthesis because Hopkins forgets to close it, resulting in it being imperfectly segregated from the surrounding text. To be more precise, the main parenthesis leads to a sub-parenthesis, and while Hopkins closes the sub-parenthesis, he forgets to close the main parenthesis.

angels presume to look upon God without reverence. Finally, the shreds "group themselves, *se dressent*, at the poles," as Satan and his ungodly crew assemble themselves at the extreme pole of rebellion and Michael and the faithful angels assemble themselves at the extreme pole of obedience. In Hopkins' analogy, then, God's judgment is a magnetic field that segregates his creatures into the opposing poles of faithfulness and disobedience.

Hopkins extend his analogy further, explaining that God's wrath "strains" Satan: "the terrible instress" of God's anger "cast[s] [Satan], with straining, in one direction" (137). To recall Rankine's definition of the term, "strain" means to bend out of natural shape. Under the duress of God's wrath, Satan twists or "takes a set" as Rankine might say. His internal strength or stress is insufficient to endure God's force. This twisting or bending of Satan reorients his nature "in one direction (which is the being cast down to hell)" – towards evil (137). Satan, obstinately resisting God's wrath, bends and is twisted by it, and his nature is crooked and perverse ever after. As in Milton, hell not only is an internal state, it is a self-perpetuating condition stemming from an originary act of disobedience.

Satan's hell and his "straining" should be compared with the speaker's conversion in the *Wreck of the Deutschland*. In the *Deutschland,* God's wrath also envelops the speaker, who exclaims "the frown of his face before me, the hurtle of hell behind, where, where was a, where was a place?" Much as the stress of God's anger "calls out fire against the Devil" within his angelic "substance," so the body of the *Deutschland* speaker is "laced with fire of stress." As Satan strains in God's wrenching ire, so the *Deutschland* narrator's midriff is "astrain" and "[leans]." Satan falls from heaven, and the narrator similarly experiences "the swoon of a heart that the sweep and the hurl of thee trod/ Hard down with a horror of height." But while Satan strains in resisting God and consequently bends or twists out of his natural form, the *Deutschland* narrator leans or strains to bend before God in submission: the speaker "did say yes," and "fled with a fling of the heart to the heart of the Host." Rather than enduring God's wrath, the speaker hides in the "heart of the Host" to escape it. Thus, he groups himself, *se dressent,* at the pole of obedience to God, or "flashes" from the "flame" of God's anger to the "flame" of God's grace. God's wrath drives him to shelter in Jesus, and ultimately the speaker finds that the fields of God's anger and grace are one and the same, the difference inhering in the subject's response: "Beyond saying sweet, past telling of tongue,/ Thou art lightning and love, I found it, a winter and warm;/ Father and fondler of heart thou hast wrung;/ Hast thy dark descending and most art merciful then."

In life, the current of God's wrath/grace alternates depending on the recipient's response, but in hell God's wrath obdurates. Nevertheless, God's wrath accounts for only half of the "textural stress" or friction causal of hell fire. The other half of the frictional mechanism stems from the condemned soul. After likening the devils to iron shreds in a magnetic field, Hopkins then compares the angels' fall from heaven to death for human beings. According to Hopkins,

> The fall from heaven was for the rebel angels what death is for man. As in man all that energy or instress with which the soul animates and otherwise acts in the body is by death thrown back upon the soul itself: so in them was that greater stock of activity with which they act, intellectually and otherwise, throughout their own world or element of spirit. (*Sermons* 137).

Not only is God's wrath a field of energy, then, but the angelic realm and the human soul are energetic fields as well. Thus, the "energy" or instress of the condemned soul is thrown back upon itself in death. But what throws it the soul's stress back upon itself? Alternately stated, "How then is the soul set at stress? As I suppose by some main stress from without, [. . .] the stress of God's anger which first 'prepared' or called into being fire against the Devil" (137).

Hopkins' hell functions by a double mechanism, then. The fires of hell stem from the friction created by an external force pressing inward upon the soul opposed by an internal force pressing outward from the soul. Externally, the force of God's wrath inverts the vital force of the soul, bending the soul's energies back upon itself. This in itself constitutes a grievous conscription of the soul's liberties, and Hopkins likens this curtailment of the soul's energies to imprisonment or blindness (138). But in bending the soul's sight and agency back onto itself, God imposes yet another penalty on the sinner, depriving the condemned of all sensation except of the deeds done in life.[211] Forcibly self-involuted, the condemned soul has nothing to experience except the "scapes" it retains of its past, the self-inscribed monuments to its past sins. When the soul "instresses" these shameful "scapes" or "species" – memories – of its past, "the pain [is] that of fire, supposing fire to be the condition of a body (and by analogy of any substance) texturally at stress" (136, italics original to text).

Hopkins subsequently elaborates this "textural" stress, explaining that the soul's natural "strain or tendency [is] towards being, towards good, towards God" (137). Thus, the natural vector of the soul's energy is outward from the self, towards life and God. Yet repulsed by the negative pole of God's wrath, the soul's strength "is broken, refracted, turned aside," and forcibly directed inward toward the scapes of its sins (137). Accordingly, the soul is set

[211] It should be remembered that for Hopkins, memories are not merely psychological in the sense of disembodied thoughts. Rather, memories are "scapes" written within the body. As bodily – in the sense of consisting of substance -- the soul retains the scapes written in life. The fact that the soul itself is a body in the sense of being substantial appears in Hopkins' description of the soul's pain as "fire, supposing fire to be the condition of a body (and by analogy of any substance) texturally at stress." Like Lodge's, Stewart's, Tait's aether bodies in the afterlife, Hopkins' condemned souls are in some way analogous to matter.

"texturally at stress" by two contrary stresses within its substance: the native stress of the soul reaching outward toward being and God, and the external force of God's anger directing the soul's force back upon itself (136). As Hopkins' writes, "the one stress or strain then encountered and clashed with the other; the will addressed [. . .] toward beatitude [. . .] towards light, is [bent backward and] confronted by that scape, that act of its own, which blotted out God and so put blackness in the place of light" (138). Unable to escape its own selfbeing, and the scapes that have been internalized within this selfbeing, the damned soul is cursed to fixate upon its past actions, and to be what it has done: "against these acts of its own the lost spirit dashes itself like a caged bear and is in prison, violently instresses them and burns, stares into them and is the deeper darkened" (Sermons 138). In Hopkins' hell, one's punishment is to be oneself, and to know oneself with excruciating clarity. As Hopkins writes in "I Wake and Feel," "I see the lost are like this, and their scourge to be [. . .] their sweating selves" (11-14).[212]

Hopkins' vision of hell may be interpreted metaphorically, and its fires and torments taken merely as an analogy for psychological remorse. Nor do I claim that remorse is not intended. Surely, when the "the lost spirit dashes itself" against "[those] acts of its own," it feels remorse (138). However, to argue that remorse is all that is intended saps the fields, stresses, counterstresses, and strains of Hopkins' energetic hell of their force. Such an interpretation ignores the repeated emphasis of the text, and dismisses the two-part mechanism by which Hopkins accounts for hell's pain. Hell for Hopkins operates by physical causation and should not be regarded as allegorical or purely psychological.

[212] Hopkins' hell is similar to Milton's in that both focus more on the fire within than the flames without. Much as Milton's Satan proclaims "myself am hell," so the chief punishment for Hopkins' souls stems from the "intellectual imagination" set afire by the pains of sensuous impressions of past deeds (*Sermons*, 136).

Like contemporary models of aether, Hopkins' model is speculative and conjectural. Whether reality works according to the exact and precise mechanisms depicted by the model is not the point. Rather, the point of such speculative models is that all reality (whether aether or hell) works according to physical process and causation, the same sort of causal processes that populate the visible world. Hopkins' model, fanciful as it may be, makes a similar case: physical continuities span substance, and energy links the material and the metaphysical.

5.8 Summary

In this chapter, I matched Hopkins' model of hell to two strains of Victorian science. I first compared Hopkins' scapes to Victorian psychology to show that for scientifically-informed Victorians, memory, thought, and sensation were material processes grounded in the physical substance of the nerves and brain. Memories specifically were the product of "sensigenous molecules," as Huxley referred to them, or of matter within the brain charged with energy and so arranged as to be "competent to [. . .] repro[duce]" a sensory impression (731). Accordingly, Hopkins' scape is an energetically charged artifact within the substance of the brain, and "constitute[s] the physical foundation of memory" (Huxley 731). In Hopkins' own words, a scape is "in fact physical and a refined energy accenting the nerves" (*Oxford Essays* 307).

Subsequently, I compared Hopkins' model of hell to contemporary scientific models of aether. I did so for several reasons. First, if scapes are material artifacts, how can they exist in a disembodied soul? Second, how can physical stresses, strains, and energy fields act in the metaphysical space or state of hell? And third, how can immaterial souls respond to and be acted upon by physical energy? Pairing Hopkins' model of hell with scientific models of aether discovers several parallels. Namely, in investigating the substrate of matter, Victorian physical scientists extended the empire of physics into territory previously regarded as metaphysical.

While physicists claimed (some more persuasively than others) to eschew metaphysical speculation, in postulating unseen forces, aethers, and universes anterior to the visible world, they effectively blurred distinctions between physical and metaphysical being. Several speculations -- which would seem radical to twenty-first century eyes if not for the scientific authority and prominence of the speculators – included even the afterlife and the soul in the expanded sweep of physical science.

Hopkins' model of hell falls in with this expanded sweep. It illustrates how Victorian philosophers stretched the purview of energy from observable relations between material objects to unobservable relations between invisible objects. In some cases, philosophers went so far as to subject all substance, grossly material or not, to physical laws and relations of energy. Eccentric as it may be, Hopkins' hell conforms to this impetus of Victorian physics in subordinating substance universally to energy.

6 CONCLUSION: INSTRESS

In this dissertation, I have argued that Hopkins' poetics of stress constitutes an adaption of Victorian energy science. More specifically, I have attempted to show that for Hopkins, the natural world and the supernatural order of creation are continuous, and that energy – or stress – unites them.[213] After an initial survey of Victorian physical science in chapter 1, chapter 2 surveyed several of the meanings of stress in nineteenth century physics and engineering, giving especial attention to Rankine's use of the term to designate a physical, yet self-defining, energy of internal coherence. Likewise, chapter 3 examined Hopkins' concentric definitions of stress, observing that while these definitions may be different, they are not incompatible, and that the

[213] By "supernatural order of creation," I mean the soul, the afterlife, the "aeonian" order of angels, and even the acts or "outstresses" of God in creation (*Sermons* 137). I do not mean the existence of God himself. See chapter 4, pages 51-2.

inner “orbits” of definition build up from the outer ones. Thus, to move from the outer to the inner orbits, stress functions as energy pure and simple, as the force an object exerts to maintain its shape, as the force by which an object maintains its material coherence, and finally as the force by which an object maintains its ontological being. In its outermost orbital of stress pure and simple, Hopkins’ stress resembles the definition accepted by most Victorian physicists. Closer to the core, in treating stress as a force by which an object maintains its shape and material coherence, Hopkins’ stress resembles Rankine’s. Yet in its innermost orbit, as a force of ontological being, Hopkins’ conception of stress passes beyond science to posit an energetic contiguity between the natural and supernatural world.

Accordingly, chapter 4 investigated the overlap of physical energy and metaphysical instress in Hopkins’ poems. Since Hopkins associates instress and energy metaphorically, the chapter interrogates the peculiar nature of Hopkins’ metaphor. Hopkins’ metaphors are unusual in that they do not posit, in Ricoeur’s words, an “absurd” negation of tenor and vehicle. Instead, the apparent similarity between compared objects suggests deeper ontological correspondence, a correspondence underwritten by Christ’s Incarnation and Great Sacrifice. In fine, Hopkins’ metaphors posit a real and actual connection between objects. Applied to his metaphors of physical energy and metaphysical instress, this feature of Hopkins’ metaphor indicates that instress is a real and actual form of energy.

Following from chapter 4, chapter 5 examined Hopkins’ commentary on Ignatius’ “A Meditation on Hell,” perhaps the most adventurous treatment of instress and energy in all of his writings. In this commentary, Hopkins treats God’s wrath and the condemned soul’s stress as two opposed fields of energy. The opposition between these two fields generates “tension” or friction within the substance of the soul, which friction sets the condemned soul afire.

Accordingly, Hopkins' hell functions physically; one might even say mechanically.[214] Although Hopkins' model of hell is admittedly speculative, in several respects it resembles contemporary scientific models of the aether.[215] These models of aether were similarly speculative, and extended known laws and relations of energy to account for phenomena yet unseen. Aether models often seem unlikely, particularly in their assemblage of grossly mechanical cogwheels, idle gears, and rotary cylinders to figure the quick motions of the subtle aether. Nevertheless, the point of such assemblages is not to identify the precise mechanics by which the aether must function, but to identify the physical function of the aether's mechanics, whatever those mechanics might be. Specifically, Victorian aether models suggested that the aether operates physically, according to the relations of matter and energy observable by science. In much the same way, Hopkins' hell operates physically, according to the relations of matter and energy as understood by Victorian science. Again, nature and the supernatural order are continuous, and energy unites them.

Several claims span this dissertation. First, the dissertation assesses Hopkins' distinctive terminology of stress, and argues that Hopkins uses this term to express the energetic relations between objects. As chapter 4 discusses, the majority of Hopkins' scholarship currently assigns stress to three loosely analogous categories of physical, psychological, and spiritual stress.

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[214] Hopkins' description of God's wrath "throw[ing] back" the soul's stress recalls his description of waves rebounding from the seawall by "mechanical reflection." Compare the hell meditation in *Sermons*, 137 with the Teignmouth seawall entry in *Journals*, 252. See also chapter 5, pages 14-16.

[215] See chapter 5, pages 62-78. Both Hopkins' model of hell and Victorian models of aether were freighted with metaphysical potential. The metaphysical significance of Hopkins' hell is obvious. The metaphysical potential of the Victorian aether appears in Tait's, Stewart's, and Lodge's speculations of the afterlife and the aether-ial composition of the spiritual body. Despite this metaphysical potential, however, both Hopkins' hell and Victorian aethers operate strictly according to physical cause and effect. Indeed, Hopkins' hell and Victorian aether models function mechanically, according to simple laws of energy.

Contrarily, from the meanings of stress traced in chapter 2, Hopkins' central poetic term stems from the lexicon of physical science. Moreover, as chapter 3 contends, the concentric definitions of stress build up from the outside in, and the ontological sense of stress at the core of the system requires the physical definitions that orbit it. Finally, as chapter 5 claims, psychological and spiritual stresses are forms of energy, and consequently may be physically described.[216]

Second, this dissertation addresses Hopkins' oddly literal metaphors and analogies. Chapter 3, in accounting for the concentric meanings of stress, observes that the term sets physical and spiritual energy in an analogical relationship that is somehow more than analogical. The fact that the metaphysical meaning of stress derives from the physical definitions subsidiary to it posits an initial connection between them. Chapter 4 extends from this, showing that Hopkins' metaphors often lack the absurd negation of vehicle and tenor that drives figurative abstraction. If Hopkins' metaphors make literal claims, then when Hopkins compares spiritual stress to physical energy, an actual relation obtains between them. Finally, chapter 5 substantiates the claim of chapters 3 and 4 by showing that spiritual and psychological stresses function physically or energetically.[217] Essentially, chapter 5 sets the mind, the soul, and even the afterlife on an energetic basis, animated by physical (physics-ical) processes, thereby justifying the analogies between spirit, psyche, and energy posited by previous chapters.

Third, and perhaps most insistently, this dissertation addresses the contiguity of the visible and invisible worlds in Hopkins' integrated universe. From this perspective, the behavior

[216] By "physically," I mean "physics-ically." As chapter 5 claims, if the nerves and brain function by physical energy (electricity), then the discipline of psychology opens to physics. Similarly, if physical relations of energy may also explain the behavior of the spirit, then physics encroaches upon metaphysics.

[217] Again, in saying that Hopkins' spiritual and psychological stresses function "physically," I mean that they function "physics-ically," or in accord with the behavior of energy described by Victorian physics and physicists.

of energy becomes a central theme of many of his poems, as well as a critical feature of his poetics itself.

I would like to conclude by pointing out how the claims above may be useful when reading Hopkins' poetry. I would particularly like to apply these claims to clarify the meaning of instress, a term vital to Hopkins' poetics and to many, if not all, of his individual poems.

James Cotter and J. Hillis Miller, in their classical definitions of stress, defined the term as a form of the metaphysical "energy" that God communicates to a thing at creation by which it exists and maintains its hold on being.[218] Leonard Cochran subsequently elaborated their definitions by distinguishing stress and instress. As Cochran writes, "both [terms] represent kinds of energy, stress the energy of the thing as it tends towards existence in general; instress the energy which keeps in existence the particular thing" (165). Thus stress affords an object the ability to be, or to exist in a general sense; instress affords an object the ability to be itself, or to exist as a particular, concrete thing.

Recent critics such as Brown, Nixon, Banfield, Hutchison, and others have recast Cochran's definitions in light of their contention that Hopkins drew from physical science to coin his distinctive poetic terms. For these critics, stress and instress derive from the study of actual, physical energy.[219] By Brown's account, stress identifies the various forces that combine to give a thing its being. Instress, then, describes the "resultant" of these component stresses, or the particular configuration or "equilibrium [of energies] which may be said to constitute [a thing's]

[218] For a fuller discussion of the critical treatment of stress and instress, please see chapter 3, pages 6-15.
[219] Each of these critics argues for the physical basis of Hopkins' poetic terms. Nevertheless, their claims exist on a spectrum. While Brown argues that Hopkins bases his poetic terms on scientific usage, he typically interprets stress and instress metaphysically, as designating an ontological force of being or existence. Nixon, on the other hand, customarily takes stress and instress to mean energy of a precisely physical and literal sort. See below.

distinctive" identity (219). Such a formulation refigures Cochran's to include physical science, but it nevertheless preserves Cochran's essential distinction of stress as a force of potential existence, and instress as a force of discrete, particular existence. Additionally, such a formulation substantially agrees with Cochran's in casting instress as an ontological force, not as an actual form of physical energy. Instress may be compared to energy, but the comparison remains merely metaphorical.

Most recently, however, critics like Jude Nixon, Marie Banfield, and Hazel Hutchison have described instress forthrightly as energy. Nixon goes so far as to equate Hopkins' instress with electromagnetic energy. As Nixon writes, "Hopkins assumes that electromagnetic energy, seminal fluid or 'instress,' flows from God" (144). According to Nixon, Hopkins' poetic vision is cosmic in scope, and institutes a "cosmic economy" in which God's instress resupplies the energy lost to entropy: "Hopkins' [cosmic] economy relies on ample supplies of energy to counter entropic degradation [. . . .] To stave off entropy and to preserve caloric equilibrium, Hopkins employs Joule's Great Architect [God] who maintains the world's energy supplies" (146). This dissertation supports Nixon's formulation of instress, and verifies several preconditions necessary to Nixon's thesis. If energy bridges the visible and the invisible world, if Hopkins' energetic metaphors for stress should be taken literally, and if the root term stress itself stems from physical science, then Nixon's understanding of instress as an actual form of energy seems justified.

Yet instress in Hopkins' poetry identifies both the energy that inheres within a thing (or in Nixon's case, within a cosmic system), and the action by which an observer perceives it. Accordingly, the meaning of instress that Cotter, Miller, Cochran, Brown, Nixon and others develop applies only to one facet of instress' total meaning. As Glenn Hughes perceptively observes, the energy of instress takes two forms. In one sense, instress applies to the "the force, the tensional dynamism, or 'stress,' that holds together a thing's form. Ultimately [. . .] instress is the active presence of God's will sustaining a thing in its being or essence" (118). Such a conception of instress closely rephrases Cochran's definition, subsequently expanded by Brown, Nixon, and other energy critics.

But in another sense, Hughes explains that instress denotes "the subject's empathic perception of [another] thing's instress, the felt apprehension of [. . .] its stress or energy of being" (119). In this sense, instressing is an act of perception, the act of taking an object of sense within oneself. In total, then, instress is an artifact (if a quantum of energy may be so described) as well as an action. Accordingly, Hopkins' poetry speaks of instress as a thing ("an instress" or "the instress"), as well as a deed to be performed ("to instress," "must be instressed").

Yet this duality of instress poses a problem: how to account for it? Is Hopkins consistent in his application of a single term to both of these instances, or is his nomenclature slovenly?

Conceiving instress energetically justifies Hopkins' dual extension of the term. As an artifact, instress designates the inner stress by which an object preserves its distinct form and nature. In terms of the orbital definitions of stress from chapter 3, I might say that this form of instress signifies the energy with which an object maintains its shape, material coherence, and ontological being. As an action, however, instress designates the psychological stress by which a perceiver takes in a sensory object. Similarly, in terms of chapter 5's discussion of scapes and the brain, I might say that the active form of instress signifies the nervous energy by which the nerves take in an object of sense and translate it as a scape or "sensigenous molecule" within the brain.

In special moments, when external pressures strain an object, the formative instress within the object is called forth and manifests outwardly.[220] Hopkins' poems and nature journals attest these instances in their observations of trees laden past their spring, of atmospheric charges giving way to flashes of lightning, and of animals and human beings revealing their hidden nature in moments of duress or high achievement.[221] At these moments, the essential energy or instress of the thing exerts itself outwardly, and may be "caught" or taken inward – instressed – by a perceptive observer.[222] Thus, Hopkins' dual application of the term makes sense in that each application represents a moment in the total sequence of energetic transfer. In short, instress represents two points on opposite ends of a process of transfer in which the energy essential to an object enters and is stored within a percipient observer. Each of the component definitions depicts either a beginning- or end-point in the larger process.

But in this process, the nature of energy should not be metaphorized to meaninglessness. If the instress within the object is an actual form of energy, so the act of instress in the perceiver must also be an energetic act. As chapter 5 discusses, Victorian physiologists conceived of perception as the transference of electrical energy along the nerves to the brain, and considered memory as a process of energy storage within the sensigenous substance of the brain. Moreover, Hopkins' knowledge of Victorian psychology appears in his energetic description of scape-formation in both his "All Words" essay and his commentary on Ignatius' "A Meditation on Hell." From this, the act of instress should be seen as energetic, not merely as a poetic metaphor for perception and remembrance. To be sure, perception and remembrance certainly are involved

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[220] Cf. chapter 2, when Robison and Rankine define an object's strength/stress as an internal force of self-coherence that an object exerts to counter external pressure. See chapter 2, pages 24 and 33-35.
[221] See chapter 3, 33-50.
[222] Hopkins often refers to the act of instressing an object as "catching" the object – cf. "The Windhover, line 1.

in the act of instress. But they are energetic processes driven by physically causation, namely by the energy outstressed from the object. Thus energy is conserved, and the energy outstressed from the object is taken within the perceiver and stored as an energetic scape.

Hopkins' poetry depicts a world of continual flux and transfer, as energies arc from God to the world, and between objects and observers. The world is a living welter of instress, and energetic transfer appears ubiquitously in Hopkins' poems. It appears in the chemical reaction of "That Nature is a Heraclitean Fire and of the Comfort of the Resurrection" that alters the speaker's matchwood to immortal diamond.[223] It dwindles in the "stupendous evening" of Hopkins' nightmarish "Spelt from Sibyl's Leaves," and "slacks" in his "Carrion Comfort."[224] It resurges in Hopkins' "Kingfisher" sonnet as creatures catch fire and draw flame in the sun's light, and objects ring their nature when struck.[225] It flames out in "God's Grandeur," from both the charged world and the Holy Ghost's bright wings.[226] And it sets the *Deutschland* awash, through the tumult of the sea's beating waves.[227] Nor is this energetic transfer limited to the mundane, visible world. Rather, it vibrates in the embodied brain and nerves, and persists with the soul in the world beyond.[228]

John Gordon observes that "when Randall Jarrell said that a poet is someone standing in a thunderstorm hoping to be struck by lightning, he might have been speaking for Gerard Manley Hopkins" (506). Gordon's quip has a serious point, and remarks the importance of energy (Gordon specifies electricity) for Hopkins aesthetically, poetically, scientifically, and even religiously. Like his contemporaries in the physical sciences, Hopkins viewed the world as

[223] See chapter 3, pages 18-20.
[224] Chapter 3, pages 38-46.
[225] Chapter 4, pages 31-46.
[226] Chapter 4, pages 52-68.
[227] Chapter 5, pages 14-15.
[228] Chapter 5, all.

suffused with subtle forms of energy that motivated visible phenomena. As Hopkins might say, the world is charged with the grandeur of God, and stars and storms deliver his stress ("God's Grandeur," 1; *Deutschland*, 45).

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