Lectio Entropia: A Contemplative Practice for Engaging Science

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Winter has a way of stripping the world down to what matters, leaving behind a clarity that is not sharp but deep. It was during a winter break between semesters that I was walking my Siberian Husky, Luna, while listening to *The Order of Time* by theoretical physicist Carlo Rovelli. I was astounded not only by the clarity of Rovelli's argument that time is largely a human construct and that entropy is the more fundamental quantity, but also by the quiet strength of his exquisite writing style.[1] I decided then that I needed to find a way to bring this book into the curriculum of my Physical Chemistry II course, which was to begin in less than two weeks' time.

As Luna and I rounded the corner and saw the warm glow of home up ahead, I felt unsure about how to incorporate *The Order of Time* into my course. I opened the door, crossed the threshold, and excitedly told my wife, herself a physicist, about the book and my conundrum. She was reading *Teaching and Christian Practices: Reshaping Faith and Learning*, edited by D. I. Smith and J. K. A. Smith, and was intrigued by the idea of adapting Christian spiritual practices for the classroom. The authors suggested that one might, for example, ask students to fast while discussing hunger or use *Lectio Divina* to engage a text. In that moment, I realized that I had found the vehicle for which I was looking. I believed that the ancient Christian practice of *Lectio Divina* might be adapted to allow my students to engage Rovelli's book in the context of Physical Chemistry II.[2]

This realization did not arise in isolation, but after years of reflection on my pedagogical journey. I have been teaching Physical Chemistry for nearly three decades, and throughout that time I have sought ways to enhance the learning experience by helping students engage the subject from a philosophical perspective. For those unfamiliar with this sub-discipline of chemistry, Physical Chemistry is designed to teach chemistry majors about atomic and molecular structure such that we begin with a thorough introduction to quantum mechanics and spectroscopy—the study of light interacting with matter—in the first semester, followed by scaling up to the realm of what we experience with our five senses in the second semester where we cover statistical mechanics, classical thermodynamics, and chemical kinetics. The importance of constructing a philosophical framework around quantum mechanics is obvious to most students due to its inherent strangeness. Thermodynamics, however, often appears deceptively familiar. I suspect that this has to do with the fact that our observations are on the scale of the familiar: heat flowing from a hot cup to a cold hand, water condensing on the surface of glass. This is all fine and good for the First Law of Thermodynamics, which states that any change in the internal energy of a system is the sum of the heat and the work, but then we arrive at the Second Law and students are once again perplexed. This is where we encounter the fundamental property that drives all physical processes in the universe—entropy.

Why Contemplation Belongs in Thermodynamics

The marginalization of philosophical and historical reflection in science courses is often attributed to a lack of time. However, I posit that the deeper reason is cultural rather than logistical. Much of twentieth-century science education inherited an implicit positivist posture that treats such reflection as peripheral to scientific work itself, rather than as integral to understanding what science is and how it proceeds.

I believe that students must develop their creative thinking skills in tandem with their critical thinking skills if they are to develop a clear, conceptual understanding of nature. Entropy, in particular, resists being reduced to a mere computational tool. It is not only a quantity that appears in equations; it is a description of the unfolding of the universe. While students can learn to calculate changes in entropy, they often struggle to grasp its deeper meaning. Contemplative engagement offers a way to slow down, to sit with the idea, and to allow its implications to surface gradually.

Contemplation does not replace rigorous analysis. Rather, it complements it by cultivating habits of attention, patience, and openness, qualities that are essential for grappling with the deepest ideas in science.

Lectio Divina as a Pedagogical Framework

In the Christian tradition, the ancient practice of *Lectio Divina*, *divine reading,* is a spiritual discipline that draws the reader into deeper communion with God through engagement with Scripture. The practice unfolds through a rhythm of silence, careful reading, meditation, response, and rest. Over centuries, it has formed generations of readers by shaping not only what they read, but how they read.[3]

I adapted the basic framework of this practice for use in the science classroom. My intent was not to introduce a religious practice *per se*, but to offer students a structured way of engaging a text that infuses the scientific concepts with deep philosophical meaning. *The Order of Time* is particularly well suited for this purpose, as it combines conceptual rigor with poetic resonance.

D. I. Smith and J. K. A. Smith note that "we are formed by the practices in which we participate, and not merely by the ideas we exchange," and that "practices are not merely 'things we do,' but rather activities that do something to us."[4] While this practice may be entirely new for many students, it is not the novelty that produces change, but the repeated engagement over time.

From *Lectio Divina* to *Lectio Entropia*

I refer to this adapted practice as *Lectio Entropia*, entropy reading. My intent was to create an assignment unlike anything students had previously encountered in a STEM course, bypassing the habits of mind they had developed over years of technical training and inviting them into a mode of engagement more commonly associated with the arts and humanities, where slow reading and interpretive reflection are treated as central rather than preparatory.

My institution was founded by, and remains in relationship with, the Congregation of Holy Cross, itself founded by the Blessed Basil Moreau in nineteenth-century France. Fr. Moreau's guiding principle for education was that "the head will not be educated at the expense of the heart." *Lectio Entropia* aligns naturally with this vision by engaging students intellectually while also inviting reflection, creativity, and attentiveness.

Daily, Weekly, and Monthly Practice

The daily practice is adapted from the description of *Lectio Divina* provided by the United States Conference of Catholic Bishops.[5] Students are introduced to the practice on the first day of the semester and are invited to approach it as a habit of attention rather than a task to be completed for evaluation.

Silencio (Silence): Students begin by finding a quiet space and setting aside potential distractions. They spend several minutes attending to their breath and letting go of thoughts about the past or future.

Lectio (Reading): Students read a short, assigned passage carefully, paying attention to ideas that spark curiosity. Passages that resonate are read multiple times.

Meditatio (Meditation): Students pause to reflect on a word, phrase, or idea, repeating it silently or aloud and allowing it to unfold.

Oratio (Response): Students write freely in a small notebook, responding to the reading. They are encouraged to include drawings or diagrams if those better express their thoughts.

Contemplatio (Contemplation): Students conclude by resting in silence, allowing focused attention to soften.

Each daily session takes approximately twenty to thirty minutes. Students are not asked to submit their daily reflections; instead, the practice is reinforced through weekly communal reflection (*Examen*) and periodic written synthesis followed by conversation (*Incarnatio*).

Once per week, the class begins with a brief *Examen*, where each student has about one minute or less to share an insight with the group. Students speak succinctly, and listening is emphasized as strongly as speaking. The goal is concise, respectful expression and attentive listening.

Once per month, students write a brief reflection synthesizing their thoughts, an exercise that I call an *Incarnatio* (an anonymized example is provided in Appendix A). This is followed by a meeting with each student individually or in small groups depending on their preference. These meetings are conversational rather than evaluative and focus on how the practice is shaping the student's engagement with course material and with their own learning.

What Changes in Students...and in the Teacher

I have used this practice in Physical Chemistry II for seven consecutive years, and over that time I have observed a clear pattern of development. Students become more comfortable with silence, more attentive to nuance, and more willing to engage ambiguity. The quality of their weekly *Examens* improves steadily, as does the depth of their monthly *Incarnatio* reflections. In this small, upper-level course, where students share a strong intellectual foundation and a well-established relationship with one another and with me, the practice has become a natural part of the rhythm of the class.

Students frequently comment during office hours that they find themselves thinking differently about time, change, and the natural world. Many report noticing details—light, motion, patterns—that they had previously overlooked. These shifts suggest not only a deeper understanding of entropy, but a change in how students inhabit scientific ideas.[6]

I have introduced related contemplative practices elsewhere in the curriculum, though necessarily in modified form. I introduced a version of the practice once in a General Chemistry I course under the name *Lectio Scientia*, using Carlo Rovelli's *There Are Places in the World Where Rules Are Less Important than Kindness*. With an enrollment of approximately thirty-five students, the weekly *Examen* was structured so that smaller groups of roughly twelve students shared together on a rotating basis. While each student spoke less frequently, all participated in listening each week. Student responses in this context were more mixed. Some were openly skeptical, and not all were immediately receptive to contemplative engagement in an introductory science course.

In several cases, however, the significance of the practice only became apparent later. Two students from that General Chemistry I course subsequently enrolled in both Physical Chemistry I and II, where they encountered *Lectio Quantum Mechanica* followed by *Lectio Entropia*. Both remarked on how transformative the experience became when revisited in a more advanced context. One student, who had initially dismissed the practice as a waste of time, later reflected on how intellectual and personal maturation allowed him to engage it more fully.

I have also employed *Lectio Entropia* in a summer course for non-science majors, where smaller enrollment allowed the practice to mirror more closely the format used in Physical Chemistry II. While the structure translated well, the choice of text remains an open question. If I were to offer the course again, I would likely select a more varied or whimsical collection of essays, while retaining the same rhythm of daily practice, weekly *Examen*, and monthly *Incarnatio*.

I have also changed through this process. Over time, I have become more comfortable introducing and promoting the practice across different courses and contexts. What initially felt experimental now feels like a natural extension of my teaching. The practice has reshaped my own approach by foregrounding attentiveness, patience, and relational presence, not only in how students engage thermodynamics and quantum mechanics, but in how I understand the work of teaching itself.

A Pedagogy of Entropic Contemplation

To understand why this practice matters, it is necessary to return to entropy itself. From a pedagogical foundation, entropy must first be described by its most fundamental definition, as codified by Rudolf Clausius in the nineteenth century. Clausius did not introduce entropy as a measure of disorder or merely as a bookkeeping term for inefficiency. Rather, he defined entropy as the transformational content of a body. In this formulation, entropy names the capacity of a system to undergo change. It is not merely an accounting of what is lost, but a description of how transformation itself is possible.[7]

Clausius's choice of language was neither accidental nor decorative. In coining the term entropy, he deliberately drew from the Greek word τροπή (tropē), derived from the verb τρέπω (trepō), meaning to turn. Across its long history, τροπή had been used to describe dynamic processes of change: the turning of armies from advance to retreat, the shifting courses of stars and planets, the changing of seasons, even transformations in human countenance brought about by health or emotion. The unifying thread in these uses is not decay, but movement, transition, and becoming.

In an 1865 paper, Clausius made this connection explicit, writing: "I propose to name the magnitude S the entropy of the body, from the Greek word ἡ τροπή, transformation." His classical education equipped him to choose a term that could bear technical precision without severing its connection to a rich semantic history. By defining entropy in this way, Clausius placed transformation—not loss—at the conceptual center of thermodynamics.[8]

The complementary interpretation of entropy as the destruction of the capacity to do useful work is physically correct and mathematically indispensable. Yet when this formulation is presented as the primary or sole definition, it carries an unintended pedagogical consequence. Students are led to believe that entropy is fundamentally a problem, a necessary evil imposed on an otherwise orderly universe. In this framing, entropy appears as the reason engines fail, structures decay, and processes become inefficient. The universe is portrayed as running down.

This portrayal is profoundly incomplete. The universe proceeds because of entropy. Without entropy, there would be no gradients, no irreversibility, no directionality to time. Chemical reactions would not proceed, stars would not burn, and life itself would be impossible. Entropy is not the enemy of structure; it is the condition under which transient structures can emerge, persist, and transform. Local order arises not in spite of entropy, but because entropy governs the flow and redistribution of energy.

When students encounter entropy first as transformational content rather than as "disorder," their relationship to the concept changes. Entropy becomes intelligible not only in equations, but in experience: in wisdom and aging, in memory and forgetting, in growth and decay, in the irreversible passage from one state to another. Entropy is not simply a cosmic tax; it is the principle of becoming.

Lectio Entropia invites students into this reframed understanding. By slowing down and attending carefully to texts that articulate entropy in both scientific and philosophical registers, students are encouraged to inhabit the concept rather than merely manipulate it. They are invited to see entropy not as a symbol of futility, but as a marker of transformation: quiet, pervasive, and generative.

By engaging the head, heart, and hands, this practice reinforces a holistic approach to scientific discovery. The head is engaged through disciplined conceptual reasoning; the heart through resonance with lived experience; the hands through the repeated, embodied acts of reading, writing, and reflection. Together, these modes cultivate attentiveness rather than anxiety, wonder rather than resistance.

In this way, *Lectio Entropia* honors both the scientific enterprise and the educational mission that seeks formation rather than mere information. It teaches students not only how to calculate entropy, but how to see the universe as a place where transformation is fundamental, irreversible, and meaningful.

Student Encounter and Transformation

When entropy is introduced as transformational content rather than as loss, students respond differently. Over multiple iterations of *Lectio Entropia*, I have observed that this reframing does more than clarify a difficult concept; it opens a space in which students begin to reflect on their own experiences of change, irreversibility, and becoming. What emerges is not confusion, but recognition.

In written reflections and one-on-one conversations, some students articulate a profound shift in how they understand time itself. Rather than experiencing time as a relentless force that erodes meaning, they begin to see it as inseparable from transformation. Change is no longer merely something that happens to them; it becomes something that situates them within a larger physical and relational reality. Entropy, once perceived as a symbol of decay, becomes a way of naming why moments matter precisely because they do not last.

One student, in a series of reflections written across the semester, described an evolving sense of connection between physical time, memory, and personal identity. Early reflections focused on the anxiety of time scarcity and the pain associated with loss and regret. As the practice continued, those reflections gave way to a strikingly different posture: time was no longer experienced solely as an adversary, but as the medium through which growth, healing, and self-understanding could occur. The student began to describe moments of stillness, walking, noticing light or weather, remembering loved ones, as instances in which the pressure of time seemed to loosen rather than tighten.

In later reflections, the same student explored the idea that identity itself might be shaped by entropy: that memory, instinct, and anticipation are bound to irreversible processes unfolding across scales far larger than an individual life. These reflections were not presented as scientific claims, but as thoughtful attempts to inhabit scientific ideas imaginatively and responsibly. What was remarkable was not the content alone, but the care with which the student held together vulnerability, intellectual curiosity, and disciplined reflection.

Such responses reveal something essential about *Lectio Entropia* as a pedagogical practice. When students are invited to engage entropy contemplatively, they are not led away from science; they are led more deeply into it. The practice does not blur the boundary between physics and personal meaning, but rather acknowledges that scientific concepts are always encountered by persons whose lives are already shaped by change, irreversibility, and time.

Importantly, these reflections do not arise from emotional prompting or autobiographical assignment; they emerge naturally from sustained attention to a concept. By restoring entropy to its original role as a descriptor of transformation, students are given permission to see themselves as participants in the physical processes they study. The result is not sentimentality, but seriousness; it embodies a deeper respect for the universe and for their own place within it.

This is the heart of the practice. *Lectio Entropia* does not aim to produce particular conclusions or experiences. It aims to cultivate attentiveness: a way of seeing that allows scientific ideas to resonate across intellectual, experiential, and relational dimensions. When this happens, entropy ceases to be a necessary evil and becomes instead a source of wonder, a reminder that the universe moves, changes, and unfolds, and that we move with it.

Expanding the Practice across Courses and Contexts

Lectio Entropia was first developed and implemented in Physical Chemistry II and refined over four consecutive years. During that time, the structure of the practice proved remarkably stable, even as my own comfort with guiding students through contemplative engagement deepened. What began as a focused experiment centered on entropy gradually revealed itself to be a more general pedagogical framework, one capable of supporting students as they encountered conceptual difficulty, abstraction, and uncertainty.

While these adaptations did not unfold in a strictly linear chronological order, they reflect a clear developmental progression in how the *Lectio* framework proved transferable across courses and student populations. The ways in which this practice adapts to different course levels, class sizes, and stages of student development have been described above; here I focus instead on how the underlying posture of attentiveness translates across contexts.

The first extension of the practice occurred in a summer core course designed for non-science majors. In this context, the *Lectio* structure was retained while the technical demands of the material were reduced. The aim was not to dilute scientific content, but to invite students with little formal background in physics or chemistry into thoughtful engagement with scientific ideas as part of a broader human conversation about time, order, and meaning. Student responses in this setting demonstrated that the practice is accessible even to those without prior disciplinary fluency, suggesting that contemplative engagement can lower barriers to participation rather than reinforce them.

Encouraged by this success, I next adapted the practice for General Chemistry I, a course populated almost entirely by first-year STEM majors. Here the challenge was one of scale. With larger enrollments and students at an early stage of scientific formation, the practice needed to support attentiveness without overwhelming fragile confidence. Using a collection of short essays by Carlo Rovelli (*There Are Places in the World Where Rules Are Less Important Than Kindness*), I referred to this iteration as *Lectio Scientia*. The focus shifted from a single physical observable to scientific inquiry itself: how scientists ask questions, confront uncertainty, and situate knowledge within a wider human context. The sustained success of the practice in this course demonstrated its scalability across class size and student experience level.[9]

The most recent adaptation occurred in Physical Chemistry I: Quantum Mechanics and Spectroscopy, a course that presents students with one of the most conceptually destabilizing transitions in the undergraduate curriculum. Quantum mechanics requires students to relinquish deeply ingrained assumptions about objectivity, separability, and determinism. While mathematical formalism is essential, many students struggle to integrate its implications into a coherent conceptual picture.

In this setting, I introduced a *Lectio*-based practice using Carlo Rovelli's *Helgoland*, referring to this iteration as *Lectio Quantum Mechanica*, the name under which it has been used in the course for the past three years. Despite the formal sound of the title, the practice does not aim to teach quantum mechanics through meditation. Rather, it invites students into attentive engagement with the conceptual foundations and relational implications of the theory. As in earlier iterations, students were not asked to extract technical results from the text, but to read slowly, reflect carefully, and notice where Rovelli's account challenged or unsettled their developing understanding of the physical world.[10]

Taken together, these experiences suggest that the *Lectio* framework is not bound to a particular scientific topic or level of technical sophistication. Instead, it appears to be especially effective at moments when students are asked to inhabit new ways of thinking, whether encountering scientific ideas for the first time, scaling up their disciplinary identity, or confronting paradigms that challenge deeply held intuitions.[11] Appendix B provides a sample reading schedule that can be used as a template to support instructors who wish to adapt the practice within their own disciplinary contexts.

Winter Clarity, Revisited

Winter returns not as an ending, but as a way of seeing. What *Lectio Entropia* has made possible, for my students and for me, is not a replacement for the technical rigor of physical chemistry, but a deepening of how that rigor is held. Equations are still solved. Problems are still worked. Yet they are approached with a different posture, one shaped by attentiveness rather than urgency, by patience rather than haste.

Entropy, understood as transformational content, invites such a posture. It asks us to notice change not only as a formal property of a system, but as a feature of the world we inhabit. When students are given time to dwell with these ideas—to read slowly, to reflect carefully, and to respond honestly—they begin to recognize entropy not as a threat to order, but as the condition under which becoming is possible.

The practice described here is offered as an invitation rather than a prescription. Instructors in other disciplines will rightly choose different texts, rhythms, and emphases. What matters is not the particular book or schedule, but the commitment to creating space within the curriculum for attentive engagement with foundational ideas. Such space does not detract from scientific education; it enriches it.

Winter clarifies. It slows us down, quiets the noise, and reveals what endures. To linger there, even briefly, is to discover that winter has more to offer than we are usually taught to expect.

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[1] Carlo Rovelli, *The Order of Time* (New York: Riverhead Books, 2018).

[2] David I. Smith and James K. A. Smith, eds., *Teaching and Christian Practices: Reshaping Faith and Learning* (Grand Rapids, MI: Eerdmans, 2011).

[3] United States Conference of Catholic Bishops, "Lectio Divina," accessed January 10, 2020, https://www.usccb.org.

[4] Smith and Smith, *Teaching and Christian Practices*, 6.

[5] Smith and Smith, *Teaching and Christian Practices*, 15.

[6] Rudolf Clausius, "Ueber verschiedene für die Anwendung bequeme Formen der Hauptgleichungen der mechanischen Wärmetheorie" [On Several Convenient Forms of the Fundamental Equations of the Mechanical Theory of Heat], *Annalen der Physik und Chemie* 125 (1865): 353–400.

[7] Ibid.

[8] Edward F. Redish, "Implications of Cognitive Studies for Teaching Physics," *American Journal of Physics* 62, no. 9 (1994): 796–803; and E. M. Carson and J. R. Watson, "Undergraduate Students' Understandings of Entropy and Gibbs Free Energy," *University Chemistry Education* 6 (2002): 4–12.

[9] Carlo Rovelli, *There Are Places in the World Where Rules Are Less Important Than Kindness* (New York: Riverhead Books, 2022).

[10] Carlo Rovelli, *Helgoland: Making Sense of the Quantum Revolution* (New York: Riverhead Books, 2021).

[11] Thomas S. Kuhn, *The Structure of Scientific Revolutions*, 2nd ed. (Chicago: University of Chicago Press, 1970).

Appendix A: Anonymized Example of an *Incarnatio*

Through the practice of *Lectio Entropia*, I began to notice how rigid my understanding of time had been. I had long experienced time as a sharp divide: on one side, a collection of meaningful moments; on the other, a constant source of pressure, loss, and regret. Yet alongside this, I have also known brief moments when time seemed to fall away entirely, producing a feeling of limitlessness sometimes described as an "oceanic" sense of being part of something larger. Over the past few years, that feeling had grown distant, replaced by a harsher awareness of time's demands. Reading The Order of Time has softened this perception. Learning that time is not a fixed, universal structure, but something relational and contingent, has allowed me to loosen my attachment to the suffering I associated with it. Rather than feeling destabilizing, this understanding has been comforting. If reality is always in flux, then no moment of difficulty or failure is permanent. Lately, this has changed how I move through the world: noticing the pace of rain, the expressions of people I love, small moments that feel unexpectedly complete. In these moments, time feels less like a force acting on me and more like something I am briefly free from.

Appendix B: Reading Schedule for *Lectio Entropia*, Spring Semester 2026.

Date	Pages
14-Jan	1 - 6
15-Jan	9 - 13 (up to section break)
18-Jan	13 (Ten Thousand Dancing Shivas) - 17
19-Jan	19 - 21
20-Jan	22 - 27 (end at section break)
21-Jan	27 (Blur) - 36
22-Jan	37 - 40
25-Jan	41 - 45
26-Jan	45 (Temporal Structure Without the Present) - 56
27-Jan	57 - 60 (end of paragraph)
28-Jan	60 (last sentence) - 62 (to end of line 6)
29-Jan	62 (begin at line 7) - 69 (section break)
1-Feb	69 (What is There, Where There is Nothing?) - 73 (section break)
2-Feb	73 (The Dance of the Three Giants) - 79
3-Feb	81 - 83 (section break)
4-Feb	83 (Granularity) - 86
5-Feb	87 - 92
9-13 Feb	**Incarnatio 1**
15-Feb	94 - 104
16-Feb	105 -109
17-Feb	110 - 115
18-Feb	117 - 124
19-Feb	124 - 128
22-Feb	131 - 134 (section break)
23-Feb	134 (Thermal Time) - 137 (section break)
24-Feb	137 (Quantum Time) - 142
25-Feb	143 - 144 (section break)
26-Feb	144 (We are the ones turning!) - 151 (section break)
2-8 Mar	*Spring Break*
9-13 Mar	**Incarnatio 2**
15-Mar	151 (Indexicality) - 153 (end of 3rd paragraph)
16-Mar	153 (In order to use…) - 157
17-Mar	159 - 161
18-Mar	162 - 166 (section break)
22-Mar	166 (Traces and Causes) - 170
23-Mar	171 - 174 (end of 1st paragraph)
24-Mar	174 (1.) *This is just one short paragraph
25-Mar	174 (2.) - 177
26-Mar	178 (3.) - end of page
29-Mar	179 - 183 (end of 1st paragraph)
30-Mar	183 (It may seem…) - 186 (see Figure)
31-Mar	186 - 189 (end of 1st paragraph)
1-Apr	189 (We are stories…) - 192
5-Apr	193 - 197 (end of 1st paragraph)
6-Apr	197 - 200 (line 2)
7-Apr	200 (I believe…) - 203
8-Apr	205 - 212
13-17 Apr	**Incarnatio 3**