Lesson Unit

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TITLE:

Light from Light: Mystery and the Life of Your Mind

TOPIC:

The nature of science, the scientific method, the humanness of science, and the idea of mystery

DESCRIPTION:

This lesson introduces students to the scientific method and in particular to its intrinsically "human" quality – that is, to the ways in which the scientific method can be practiced only by human beings whose commitments and reasoning are shaped by sources and methods besides the scientific method. In addition to a discussion of the role played in science by human desire, faith, freedom and moral judgment, there is an in-depth historical and philosophical look at the role played by mystery, and especially the mystery of God. By introducing the scientific method as an authentically "human" method, this lesson attempts to refute those who dismiss religious faith merely because it appeals to faith, mystery and God. While there are, of course, important methodological differences between various sciences (for example, many of the tools used in astronomy are different from those used in zoology), this lesson concerns "the scientific method" in a way that reveals certain assumptions that exist universally in the practice of science.

ESSENTIAL QUESTIONS:

1. What are the steps of the scientific method and what makes it a distinctively human undertaking, as opposed to a mechanical or formulaic process?
2. Does the philosophical ideal typical of our modern age - an ideal that is exemplified in famous philosophers like René Descartes and Thomas Jefferson - contrast with how science is actually practiced? In other words, does science allow for mystery, or can all knowledge be reduced to scientific ideas that are clear and distinct to the human mind?
3. What is the relationship between God, at least as Christians understand him (as the *Logos*), and the life of our mind?

KNOWLEDGE that students participating in our lesson will gain:

1. Explain the four steps of the scientific method: their definitions and relationships.
2. List four ways in which the practice of science is a distinctly human activity.
3. Recognize the difference between the modern idea of reason and mystery (e.g., René Descartes) and the contemporary idea of reason and mystery in physics (e.g., the paradox of light).
4. Recall the statement of St. Augustine: "If you can comprehend it, it isn't God." Explain how the incomprehensibility of the *Logos* behind all reality gives life to our reason.

SKILLS that students participating in our lesson will gain:

1. Analyze a statement to judge whether it belongs to the kind that can be produced by the scientific method, or whether it results from some other method (e.g. philosophical or theological).

2. Explain at least two of the four ways given in this lesson in which science is a specifically human activity. That is, express in your own words at least two of these philosophical observations about the human character of science.
3. Trace the historical development in science from rejecting to accepting the idea mystery in physics by referring to Rene Descartes, Albert Einstein and the contemporary understanding of light.
4. Explain how the mystery of God gives life, rather than frustrates, the rational mind of the scientist and philosopher. Employ the analogy between God and reason, on the one hand, and, on the other, the physical horizon and our sight.

METHOD:

This lesson unfolds over three 50-minute periods. It is **ideal** to have both a science and a theology teacher present for every period. Even if they are not always team teaching, their mere presence together will lend credibility to the lesson as a whole, and thereby encourage students to pursue the harmony between faith and science and integrate their worldview.

Lesson Timing: three 50-minute periods:

1. first period: activity and explanation of the scientific method;
2. second period: philosophical exploration of what makes it a "human" method; and
3. third period: historical and philosophical exploration of mystery in science and faith.

First Period: The Scientific Method

1. Lesson Plan Structure:
    a. Explanation of the Scientific Method
        i. **Introductory Activity (10-15min)**: *The Nature of Science* (click the link or see the PDF among the resources for this lesson) to introduce the necessity of human engagement in the practice of science, and therefore also the fact of its limitations; science cannot be reduced to a system of impersonal rules or mechanical processes; science requires a kind of faith (i.e., a faith that the puzzle actually works); it requires a desire or love for knowledge that expands with every new paradigm (i.e., a desire to set aside the first square to incorporate the new piece/data into the larger square). Let students know that these human features and others will be explored further on the second day.
        ii. **Explanation of Steps of Scientific Method**: Explain the steps of the scientific method and try, if possible, to connect them to the introductory activity (e.g., the step of observation is the moment of analyzing shapes; the step of hypothesis is the initial idea for their configuration; the step of experiment is moving the pieces together; and so on).
            1. Observation;
            2. Hypothesis;
            3. Experiment;

a. When introducing the idea of experiment, one can emphasize that experiments should be designed *to refute* the hypothesis (rather than confirm it), in order as much as possible to resist the influence of scientific bias, or the way that antecedent theories already shape the way we design experiments and therefore already channel us toward or away from various theories and explanations. Our background knowledge interprets not only the data but what even counts as data;

4. Modify and add experiments as necessary until a theory rises and stands until further observation disqualifies it.

Second Period: The Humanness of the Scientific Method

Philosophical Observations about the "Human" Character of Science. On this day, there is some time to finish the previous lesson. But eventually the class should transition to a Socratic discussion of such topics as the following:

1. **Desire:** Why would a scientist give ten, twenty, thirty years of his or her life to science? What do scientists want? How badly do they want it? Passion or curiosity is a human attribute - as animals we have motives and desires, and as rational animals we have intellectual motives and desires. Passion draws us to search for answers, to sacrifice years and years in a laboratory in order to find answers. Thus, science lives only by human passion. A computer calculates according to rules, and it can never wonder or become fascinated by questions that fall outside the domain of bit-patterns it recognizes. If a computer program receives input outside the boundaries it was designed for, it either crashes or ignores that input (depending on how well the program was written). But when a human receives something new, it wonders and sets out to explore.
2. **Faith**: How do scientists know there even *are* answers to their questions? Why do they not expect there to be an absurdity at the end of their research? What do they believe about reality that gives them the confidence to invest their lives in pursuit of real, rational answers? We must realize that reason lives on faith, or that prior (a priori) commitments are necessary even to begin research: for example, I must be committed to the intelligibility of the universe (that there will be "answers" to our questions); that our mind corresponds to this intelligibility (that our mind is an image of the Divine Mind). Here we can point out the ambivalence of posing the question about the relationship "between" faith "and" reason – *for reason itself lives by faith, and faith must be rational in order to be authentically human*.
3. **Freedom**: What does it mean to search for the truth? Does this search involve our freedom? If what we say and think is absolutely determined, is it possible to assent to something *because it is true* (and not because we are forced to *think* it is true)? We choose to assent to the answer because it is true, and thus we assent by a spiritual power like free will – and not because we are helpless machines "holding" and "enunciating" statements like Siri or Alexa (or any other AI device). We can reject things *because they are false*, and not simply because we are helplessly programmed to move toward some things and away from others.
4. **Moral Sense**: Are there unethical or immoral ways to perform scientific research? Can science alone tell us which forms of scientific research are immoral, or do we need to appeal to another form of reasoning? Science tells us what we *can* do, but can it tell what we *should*

do? Only a human being, a creature with a moral sense, can distinguish between legitimate and illegitimate research methods, such as, for example, the Nazi methods of experimenting on human beings without their consent and in ways that harmed their human good; other examples in American history are Henrietta Lacks, the eugenics movement or the Manhattan Project; contemporary examples include stem-cell research that destroys human embryos, and other, admittedly more speculative research methods surrounding CRISPR and the attempt to genetically design out all faults (students can watch *Gattaca* for a dramatic portray of the ethics involved in genetically engineering human beings). More generally, we can raise the morality of truth telling, and how the scientific project relies upon honesty and solidarity.

Third Period: Reason, Mystery and God

Work through the PowerPoint on the history and philosophy of mystery in modern science. Begin with the first four slides, then watch the video on the fifth slide, and then conclude with the remaining three slides.

- PowerPoint Slides
    1. John 1 & Wisdom 11:20
    2. Galileo
    3. Descartes
    4. Keats
    5. Watch video *Light from Light*
    6. God as Horizon
    7. Augustine
    8. Psalm 36:10

The key in this third period is to set up the video by introducing the problem: modern scientism tries to suggest that all knowledge is clear and "distinct" (Descartes) and that all reality can be "conquered by rule and line" (as the nineteenth-century Romantic poet Keats complains, and as contemporary scientific atheists like Richard Dawkins alleges in *Unweaving the Rainbow*, the title of which is inspired by Keat's poem cited in the PowerPoint). **But this is an unreasonable distortion of a properly Christian claim**. To be sure, all things were made through the Logos (John 1:1-3) and thus all reality is rational or can be measured by "number and weight" (Wisdom 11:20). Thus, the protagonists of the scientific revolution were justified in believing that the world was written in "mathematical language" (Galileo). But to believe in the Logos or intelligibility of all reality is one thing; it is quite another thing *to claim that intelligibility is limited to the discrete and abstract quantities of mathematics conceived by the human mind*. On this point, students can be invited to appreciate the nuance of Galileo. He says "it is humanly impossible to understand a word" of the universe "without" the language of mathematics; mathematics is necessary to understand the world. But while we cannot do "without" math, Galileo does not say that we need *only* math. Thus, this protagonist of modern science was arguably open to allowing his methods to be complemented by others that were less clear and distinct than arithmetic and geometry. Descartes, on the other hand, seems less open, since geometry set the epistemological ideal (or the standard by which real knowledge is measured) for his entire philosophy – that is, for how he wishes to handle all "the problems of the other sciences" that he treats. We should ask ourselves why someone might be attracted to the Cartesian approach to science. Does Descartes' uniform and abstract method promise a power to manipulate or control nature that we find appealing?

After reviewing the initial slides and setting up the problem, the video *Light from Light* should be easy to appreciate. It begins with Thomas Jefferson's desire for clear and "distinct" ideas (catch the allusion to Descartes, whose thought was crucial in the Enlightenment culture represented by Jefferson). And then the video shows how our most scientifically authoritative theories about light in fact presume the opposite of Jefferson's and Descartes' idea of reason. Contrary to what they believe, reason can and must be ready to try to know a reality that transcends our conceptual schemes. We cannot reduce all reality to what is for us clear and distinct; for if we try to do so, we falsify reality. Thus, contemporary science accepts the paradox of light as *both* a particle *and* a wave, without trying to reduce one set of experiments and language to the other. From here the video returns to the mysteries of the faith. Once we have accepted that reality is richer than what we can analyze and control with our own conceptual models, we become ready to recognize the great Mystery who gives life to our minds. We can see that the foolish person is not the one who believes

in God, who is the Transcendent Logos through whom all things come to be and who therefore guarantees their intelligibility and justifies the free play of our minds. The foolish person is the *proud* person who refuses to bow his head before the Mystery simply because it transcends him. The foolish person is the one who refuses in principle to believe; he refuses to accept anything above himself. Meanwhile, the wise man is the one who knows his position within reality, and therefore is ready to open himself in trust to what transcends him.

After the video the third period can finish with a discussion of the final slides. The first one after the video is from Augustine. The next contrasts the idea of "mystery" as irrational contradiction with the Christian idea of mystery as a kind of "horizon" for our mind. The final slide can be treated like an exit from the presentation. It is a beautiful quotation from Scripture (Psalm 36:10) wrapping the lesson together around the mystery of light, which can be considered either physically (particle and wave) or spiritually (the Logos that transcends us and by which we see all things). These slides should all express how the Mystery of God, far from frustrating reason, in fact gives it life. Why else would our reason so confidently run across reality searching for its intelligibility – in science, philosophy, history and human experience – if it did not *believe* in the Logos behind it all?

ASSESSMENT SECTION:

There will be a pre-assessment and a post-assessment. In addition to facilitating the measurement of progress in learning objectives, the pre-assessment will prime the students for learning by inviting them to put something into question that beforehand they might have taken for granted. The first quantitative question in both the pre-assessment and the post-assessment is a universal question, i.e., one to be asked across all lesson units.

Pre-Assessment – Quantitative Questions Only

1) The teachings of Science and Religion often ultimately conflict with each other.
    a. strongly disagree
    b. disagree
    c. unsure
    d. agree
    e. strongly agree
2) The word "mystery" legitimately refers only to what is currently unknown by humans; if given enough time and resources, human reason could, through the progress of science, eventually know everything and eliminate all mysteries.
    a. strongly disagree
    b. disagree
    c. unsure
    d. agree
    e. strongly agree
3) Truly rational knowledge will always be "clear and distinct" like numbers or precise measurements; anything "cloudy and indefinite" in our knowledge must be lamented as an obstacle to reason.
    a. strongly disagree
    b. disagree
    c. unsure
    d. agree

e. strongly agree

4) The Biblical idea of the Creator actually establishes the coherence of human reason as a faculty by which we can know the objective truth about reality.

a. strongly disagree
b. disagree
c. unsure
d. agree
e. strongly agree

Post-Assessment – Quantitative Questions (same as the Pre- Assessment)

1) The teachings of Science and Religion often ultimately conflict with each other.

a. strongly disagree
b. disagree
c. unsure
d. agree
e. strongly agree

2) The word "mystery" legitimately refers only to what is currently unknown by humans; if given enough time and resources, human reason could, through the progress of science, eventually know everything and eliminate all mysteries.

a. strongly disagree
b. disagree
c. unsure
d. agree
e. strongly agree

3) Truly rational knowledge will always be "clear and distinct" like numbers or precise measurements; anything "cloudy and indefinite" in our knowledge must be lamented as an obstacle to reason.

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4) The Biblical idea of the Creator actually establishes the coherence of human reason as a faculty by which we can know the objective truth about reality.

a. strongly disagree
b. disagree
c. unsure
d. agree
e. strongly agree

Post-Assessment – Qualitative Essay/Project Prompts

1) To demonstrate your understanding of the scientific method, pick a famous scientific theory and research its history. What was the initial observation that piqued the curiosity of the scientist? What was the initial hypothesis? What experiment was designed to confirm it? The results of this research can be presented either in an essay or in some other form.
2) To demonstrate your understanding of the human character of science, read a biography about a famous scientist and write a report or prepare a presentation that emphasizes the role of the humanity of the scientist in his/her discoveries. Explore in detail the passion, faith, freedom and moral sense underlying this scientist's pursuits.
3) To demonstrate your understanding of "mystery" as an essential category for human thinking, reflect philosophically on what it would mean to claim that everything about the human person can be "classified" or put into "distinct" conceptual boxes? If everyone is in some way unique, can any of us be *completely* understood as an instance of a general type ("classified")? In other words, do you see a connection between mystery and the dignity of every person?
4) As explained in *Light from Light*, we do not grasp scientifically the reality of light in a single idea that is clear and distinct. On the contrary, our mind can grasp it – to the extent that it can – only through a paradoxical resolution of two distinct ideas, or two separate ideas that cannot be reduced to each other (i.e., light as a *particle* and light as a *wave*). Is there any mystery of Catholic faith that you find easier to believe, now that you are able to imagine the harmony between reason and mystery (or paradox)?
5) St. Augustine famously said, "If you can comprehend it, it isn't God." To demonstrate your appreciation for the Christian idea of God as Mystery, explain the truth of this statement from St. Augustine using the image of our physical sight and the horizon. Can our creaturely minds comprehend the Creator? Should not the Creator, if he really is the Creator, be what reaches around or comprehends us (like the horizon)?
6) To reflect on the connection between mystery, reason and moral virtues like humility, consider how awe and wonder animate the life of our minds. What would our minds do – either in the natural sciences or in theology – if they could not adore what is beyond them? Have you ever been excited to spend hours repeating a simple puzzle (or something you have mastered)? By contrast, have you ever been excited to spend hours working together with others on a massive 1,000-piece puzzle? What if there were an infinite-piece puzzle that we could never finish and that therefore allowed us always to enjoy the delight of making connections and seeing more? Could that be what God is like?
7) Christians call "God" the one responsible for the existence and rationality of all being. If that is what we mean by God, can scientific atheism be coherent? In other words, can science deny the existence and rationality of what it investigates? Do you think scientists, as human beings, can afford to ignore the deeper philosophical questions we all must pose in order to give an account for the ultimate origin of reality? What are the consequences of atheism for our reason? If the atheist refuses to believe in the absolute origin that has made all things with "measure and number and weight" (Wisdom 11:20), what, if anything, could he believe instead and still practice science? If God is essential to reason, in what kind of culture should science be taught and practiced?

RESOURCES:

1) The PDF *The Nature of Science*
2) The PowerPoint *The Mystery of Light*, in which is a link to the video *Light from Light*