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Chapter Two

The Theological Origins of Engineering

BRAD J. KALLENBERG

Knowledge of our roots can sometimes help us figure out how we *ought* to proceed. Many claim that engineering began in ancient antiquity with the Egyptian pyramids, Archimedes' inventions, or the Roman aqueducts. Others give contemporary engineering a more recent history, tracing its origins to the Industrial Revolution or the Enlightenment. Yet what is often overlooked is the fact that contemporary engineering owes part of its identity to medieval monasticism. The advantage of remembering this history is the bearing it has on the questions "What is engineering for?" and "How ought engineering be practiced?"

Michael Davis makes the claim that, in Western thought, engineering has always played second fiddle to science because we in the West have been bewitched by the myth that engineering is nothing but applied science. But engineering is not merely applied science. Engineering has its own distinctive identity. In the first place, Davis claims that engineering can be distinguished from science by the sheer magnitude of the projects undertaken. Constructing a bridge, building a dam, raising a skyscraper are all tasks that require a great deal of cooperation, the sort of cooperation with which the lone inventor or isolated

research scientist may have little experience. Of course, if Hobbes is to be believed about the unstable nature of society, the only body capable of the organization and coercive leadership necessary for such large-scale cooperation is the military. Consequently, Davis traces the origins of modern engineering to the seventeenth century, when France boasted an army of 300,000 foot soldiers. For the first time in European history, those foot soldiers who operated the big weapons became organized into a special unit—the *corps du génie*—a term that connotes both the "engines" of war and the "genie" or magic associated with their function.[1]

Although the seventeenth-century corps members are probably best thought of as proto-engineers, the officers of this unit (*officieurs du génie*) began to undergo a formal training (in mathematics, technology, and officer training) whose curriculum differs only slightly from that of today's schools of engineering.[2] Thus what had begun as École des Travaux Public (the School of Public Works), by 1794 became École Polytechnique. This institution is still in operation and its curricula became the model for the first school of engineering in the Americas, namely, the US Military Academy at West Point.

In a moment I will explain why I think Davis's account is incomplete, if not downright wrong. Yet there is much to be said for it. Who could disagree that warcraft was the soil in which even the smallest technological advance blossomed with importance to the end that each was coopted for military use? Famously, the invention of the stirrup secured the superiority of the Frankish cavalry over their more loosely seated opponents in the eighth century just as the development of a better trigger enabled William the Conqueror to utilize crossbows to overpower his Norman opponents in the eleventh.[3]

Moreover, engineering has a distinctive domain of knowledge. As is often the case, with specialization comes a sort of tunnel vision. Perhaps this helps to explain the enduring tendency of engineers to be more enamored with "engineering as an end in itself rather than as a means to satisfying human need."[4] On the one hand, if engineers are descendants of military officers, then they have been trained and bound to do as they are commanded. On the other hand, each generation of engineers is entrusted with a growing and specialized body of knowledge the mastery of which requires successively greater and

greater amounts of time and attention. Consequently, it is not surprising that engineers today are easily caricatured as task-oriented folk who are more apt to keep their noses to the grindstone than to trouble with the "why?" questions that seem to lie outside the purvey of engineering itself.

Many (and I among them) feel that the tunnel vision, which is so stereotypical of contemporary engineering, points to a lamentable failing. If "doing one's job" does not automatically indemnify soldiers acting under orders, why should engineers be excused from making ethics or economics or politics their business? While Davis concedes that this tendency may appear troubling, he explains that treating engineering as an end in itself is not identical to tunnel vision and therefore not necessarily a bad thing (though it may be). Although engineering was conceived and birthed by the military, he argues, it matured during the Age of Enlightenment, a time rife with the optimism that scientific learning in every form "would bring peace, prosperity, and continuous improvement."[5] The conclusion Davis wants his readers to draw is that engineers may be somewhat justified in their narrow preoccupation with technical brilliance because the enterprise by its very nature as an offspring of the Enlightenment cannot but serve human need and improve society. Therefore, the concentration with which engineers treat engineering as end in itself in lieu of attention to broader social issues need not tarnish the image of engineering as a morally oriented enterprise.

Davis does have a point. Engineering has an excellent track record in the service of human need. And in large measure, this track record functions as a gyroscope that helps engineering stay on course despite the tangential impetuses of governmental agendas and business "needs." However, I am not convinced that this gyroscope, while absolutely necessary to the continued flourishing of technical expertise, is a sufficient condition for engineering as a whole to maintain its moral bearings. There is a latent ambiguity in engineering's self-understanding. If human life is for increasing market share in a capitalist economy, then designed obsolescence is a reasonable engineering strategy. If human life is for protecting the security of one's people against others, then engineering's four-hundred-year-long allegiance to the military is entirely appropriate. The question, "What is human life for?" has

enormous bearing on the practice of engineering.[6] Therefore, engineers may benefit from an account of engineering history that is already steeped in an account of what human life is for.

The story I wish to narrate takes us back to the twelfth-century monastery of St. Victor in Paris. I will argue that what they called "mechanical arts" is a forerunner of what we today call "engineering." Central for my purposes is the *Didascalicon,* written in the 1120s by Hugh of St. Victor. It not only exemplifies a theological model for understanding the identity of engineering, it has bearing on how engineering ought to be practiced.

It is not altogether clear when in history "mechanical arts" becomes recognizable as proto-engineering or when engineers successfully shed their longstanding class stigma. The earlier one looks in ancient history, the more disparaging is the view toward mechanical things. Archimedes (d. 212 BCE) may have saved Athens with his contraptions, but as Plutarch explains, he did so shamefully, fully aware of Plato's "indignation at [mechanical arts], and his invectives against it as the mere corruption and annihilation of the one good geometry."[7] Likewise Plato's contemporary, Xenophon (d. 354 BCE) makes it clear that no true gentleman practiced "mechanical arts." Xenophon reports Socrates' exclamation:

> [N]ot only are the arts which we call mechanical [*banausikai*] generally held in bad repute, but States also have a very low opinion of them,—and with justice. For they are injurious to the bodily health of workmen and overseers, in that they compel them to be seated and indoors, and in some cases also all day before a fire, and when the body grows effeminate, the mind also becomes weaker and weaker. And the mechanical arts, as they are called, will not let men unite with them care for friends and State, so that men engaged in them must ever appear to be both bad friends and poor defenders of their country. And there are States . . . in which not a single citizen is allowed to engage in mechanical arts [*banausikas technas*].[8]

Mechanical arts, in other words, were for slaves.

But what activities fall under the domain of "mechanical arts"? As indicated by Xenophon's words, the mechanics (*banausous*) spent a large part of the day at the foundry (*baunos* was the forge, or furnace). So smithing is implicated as undignified. But evidently warcraft is not. Nor is agriculture. Socrates goes on to assert that these latter activities are for gentlemen.

At first blush, Aristotle's three-fold division of the rational soul into theoretical, practical, and productive reasoning holds more promise for elevating the status of manual crafts. But Aristotle (d. 322 BCE) could not resist falling prey to the hierarchy of the disciplines that gives wisdom (*sophia*) clear priority over intelligence (*phronesis*) and intelligence explicit reign over craftsmanship (*techne*—as in "technology"). To make matters worse, Aristotle also perpetuated the pejorative sense of "mechanical" (*banausous*). So uncontestable is the slur against all things mechanical that in the *Nicomachean Ethics* it is simply translated as "vulgar"![9] Similarly, in the *Politics* he writes that

> any occupation, art, or science, which makes the body or soul or mind of the freeman less fit for the practice or exercise of excellence, is mechanical; wherefore we call those arts mechanical which tend to deform the body, and likewise all paid employments, for they absorb and degrade the mind.[10]

If we leap ahead eight centuries to the close of Plato's Academy—simultaneous with the founding of the Order of the Benedictines in 524 CE—we will discover that among intellectuals not much has changed. Consider Boethius (d. 524 CE), arguably the most significant philosopher-theologian between Augustine of Hippo (d. 430 CE) and Thomas Aquinas (d. 1274 CE). He divides the love of wisdom (*philosophia*) into two disciplines only, theoretical and practical, entirely neglecting to mention productive (mechanical) arts. When Isidore of Seville (d. 636 CE) compiles his encyclopedia a generation later, he acknowledges a number of disciplines that lie outside the classic seven that constitute liberal arts.[11]

Most striking is the inclusion of mineralogy alongside the eminently reputable enterprises of medicine and agriculture. But unfortunately, Isidore did little to improve the social standing of the mechanical

arts. His fascination with etymology led him to mistake the Latin *mechanicus* as derived from the Greek *moichos*, meaning "adulterer" rather than from *mechane* (machine) and *mechos* (a means, something expedient, a remedy). To his credit, there is some plausibility for this mistake. Martin of Laon (d. 680 CE) takes Isidore to mean that the ingenuity of a mechanism was akin to the secret doings of an illicit sexual affair:

> from "moechus" we call "mechanical art" any object which is clever and most delicate and which, in its making or operation, is beyond detection, so that beholders find their power stolen from them when they cannot penetrate the ingenuity of the thing.[12]

But of course Isidore's genealogy could not help but accentuate the stigma that afflicted artisans and remind them of their proper place at the bottom of the feeding chain. Perhaps this stigma explains why the Cistercian Order (founded 1098 CE) explicitly forbade "profane" learning and aimed to "make of every monastery a 'school of charity' only."[13] Human life was for the love of God and neighbor, but evidently mechanical arts lay outside the pale of such love.

The situation would change in the twelfth century. Hugh of St. Victor (d. 1142 CE) presents the first cogent challenge to the mechinists' stigma by offering a theological account of the practice of mechanical arts. Granted, Hugh's account was not without rivals: his contemporary, William of Conches (d. 1154 CE), disdained the mechanical arts as merely menial.[14] The difference between Hugh and William lay in their starting points. While William began anthropologically with human knowledge (*scientia*), Hugh began theologically with the doctrine of "sin."

The ancient Greeks explained evil in the world as the residual effect of an eternal battle between the powers of good and evil. Evil was not only conceived as a something, it was an eternal something. Thus, in the beginning was chaos. But Augustine, writing a millennium after Homer and clearly Hugh's hero, could not dignify evil with substance, much less with eternality, for as scripture spelled out, "in the beginning, God . . . ." In other words, in order to affirm monotheism, Augus-

tine was bound to describe evil as having a temporal beginning. And, in order to avoid the conclusion that God created evil, Augustine insisted evil wasn't a substance, but an absence; evil was a defect that entered the picture some time after God had created an entirely good world.

Whence evil? Evil was a distortion in the order of creation effected by a misuse of creaturely freedom. How so? In order for creation to be a uni-verse (rather than a multi-verse), creation embodied a single hierarchy of value.[15] The human soul operates correctly when it ascribes that quality of love appropriate to the object in light of its place on the hierarchy. Augustine (following Plato) considered the order itself every bit as real as the tangible objects that populated the hierarchy of the created world. Evil entered when human beings re-ranked the hierarchy of creation, ascribing an inordinate quantity of love to one or more of the rungs of the hierarchy. In the Apostle Paul's words, "For they exchanged the truth of God for a lie, and worshiped and served the creature rather than the Creator, who is blessed forever."[16] In essence, human mis-valuing was a distortion of the order of creation. The change was very real, although it was a distortion they bore within themselves, for a disordered love is a disordered soul. Thus, disordered human love manifests itself sometimes as greed, other times as jealousy, covetousness, pride, and so on. This condition had the unpleasant consequence of being perpetual, because one could only make moral progress if one possessed a faculty for indexing the progress made. And it was this very faculty, namely love of the Good, that could not be trusted.

But the bad news does not stop with human depravity. Once human beings, viceroys of creation, became incapable of rescuing themselves (*non posse non peccare,* not able not to sin), the creation they were supposed to tend fell under a curse. Christian scripture aptly expresses its undeniable reality:

> For the anxious longing of the creation waits eagerly for the revealing of the sons of God. For the creation was subjected to futility . . . in hope that the creation itself also will be set free from its slavery to corruption into the freedom of the glory of the children of God.

> For we know that the whole creation groans and suffers the pains of childbirth together until now.[17]

Whether we call this curse "sin" or "entropy" makes little difference for my argument. The fact of the matter is: iron rusts, people sicken and die, and things fall apart.

This then is the theological view of human existence that Hugh inherits from Augustine. As fallen creatures, human beings have forgotten who they are and whose they are. Nevertheless, Hugh writes, "we are restored through instruction, so that we may recognize our nature."[18] God in his redemptive grace and wisdom has intended the very condition of human fallenness as the impetus for human pursuit of Wisdom, a quest which is the "highest curative in life."

> And so arose the pursuit of that Wisdom we are required to seek—a pursuit called "philosophy"—so that knowledge of truth might enlighten our ignorance, so that love of virtue might do away with wicked desire, and so that the quest for necessary conveniences might alleviate our weaknesses. These three pursuits first comprised philosophy. The one which sought truth was called theoretical; the one which furthered virtue men were pleased to call ethics; the one devised to seek conveniences custom called mechanical.[19]

In this passage Hugh asserts that the redemption of the soul is assisted by the practice of "arts" that correspond with all the powers of the soul. Corresponding to the understanding (*intelligentia*) are both the theoretical arts (that is, the contemplation of necessary truths; here Hugh intends theology, physics, and mathematics) and the practical arts (namely, the practice of morality and the cultivation of virtue). Corresponding to knowledge (*scientia*) are all the mechanical arts. These latter have to do with feeding, fortifying the body against harm, and the contrivance of "remedies" for alleviating physical weakness (I.8, p. 55).

Hugh's account is a "*nouveau explicitement,*" a brand new way of thinking.[20] By paying more attention to the doctrine of the human fall

into sin, Hugh is able to move beyond his forebears (such as Boethius) and include mechanical arts under God's plan of redemption. Mechanical arts have to do with countering the effects of the curse, just as theoretical and practical arts have to do with countering the effects of human depravity, through the knowing and following of a gracious God on a redemptive path.

Hugh's inclusion of the mechanical arts is no small feat, for "mechanical arts" by his day had evolved into a very broad category. To be specific, mechanical arts was comprised of seven classes of practices: fabric-making, armament, commerce, agriculture, hunting, medicine, and theatrics.[21] These seven name families of practices. For example, "hunting . . . includes all the duties of bakers, butcher, cooks, and tavern keepers," as well as those who actually do the gaming, fowling and fishing (II.25, pp. 77–78). And "armament" included material science, even metallurgy: "To this science belong all such materials as stones, woods, metals, sands, and clays" (II.22, p. 76). With this last move Hugh has managed to embrace even the grimy-faced smithy so consistently maligned for sixteen centuries.

Though fiercely loyal to Augustinian theology, Hugh parts company with Augustine's Platonic division of human arts into physics, ethics, and logic, opting instead for Aristotle's quaternary of theoretical, practical, productive, and logical disciplines. Under Hugh's hand, "productive" arts expands to include all mechanical arts known to him and "logic" alone becomes the special domain of philosophy that governs the consistency within each art and between all the arts.

Hugh argues that, as a theologically legitimate enterprise, mechanical arts were governed by logic every bit as much as were theoretical and practical arts. This means that mechanical arts can be evaluated for how well they aimed at the human Good. Since Hugh could not conceive of any human Good other than that revealed by the divine Wisdom, all of the mechanical arts aim at redemptive love. To cite one example of this redemptive vision at work, Hugh asserts "commerce" as the mechanical art that aims at reconciliation of strangers: "The pursuit of commerce reconciles nations, calms wars, strengthens peace, and commutes the private good of individuals into the common benefit of all" (II.23, p.77).

In Hugh's mind theology and mechanical arts are mutually supportive. The ends of mechanical arts are displayed by the physical things contrived by the artificer. As these ends are theological in nature (they aim at the Good revealed by God), mechanical arts benefit theology by rendering visible invisible things. A bridge is not merely a convenience, it is also a means of cultivating friendship between rival villages on opposing banks. Theology in turn benefits mechanical arts by providing a benchmark for assessing the aptness of its aims. But Hugh is quick to caution against mistaking worldly theology (a theology that moves from human experience to the knowledge of God) for graced theology (a theology that moves from knowledge of God to human experience). In his *Exposition of the Heavenly Hierarchy,* Hugh writes:

> Invisible things can only be made known by visible things, and therefore the whole of theology must use visible demonstrations. But worldly theology adopted the works of creation and the elements of this world that it might make its demonstration in these. . . . And for this reason, namely, because it used a demonstration which revealed little, it lacked ability to bring forth the incomprehensible truth without stain of error. . . . In this were the wise men of this world fools, namely, that proceeding by natural evidences alone and following the elements and appearances of the world, they lacked the lessons of grace.[22]

What are these lessons of grace? For Hugh grace is not something added on top of nature, but something that permeates the world and with which human beings may keep step. "Grace," writes Hugh, is the powerful medicine perpetually offered by God "to illuminate the blind and to cure the weak; to illuminate ignorance, to cool concupiscence; to illuminate unto knowledge of truth; to inflame unto love of virtue."[23] In contrast, worldly theology is like tugging at one's bootstraps. It reveals little, and therefore has little to say to mechanical arts, precisely because it ignores God at the outset. Worldly theology begins with an empirical study of "pure nature" and then attempts to reason up toward the possible existence of a divine realm. But graced theology

unblinkingly assumes that creation is already shot through with the presence of God. Wherever one points is God's world. Human beings live as creatures under a creator whose divine wisdom is the archetypal exemplar of creation.[24] Granted, evil happens. But the undeniable fact of evil only serves to corroborate strongly the biblical story that human beings are fallen creatures inhabiting a cursed world. The Fall and its effects are universal in scope (how could it be otherwise?). Nevertheless, even in their fallenness, human beings are redeemable in the pursuit of divine wisdom by means of exercising theoretical, practical, and mechanical arts. The final end of mechanical arts is reunion with God through the pursuit of divine wisdom as well as the alleviation of physical weakness stemming from the cursedness of the created world.

Three conclusions can be drawn from Hugh's *Didascalicon*. First, in Hugh's day the growth of technology was already noticeable enough to require a fresh classification long before the seventeenth century that figures so prominently in Davis's story of the identity of modern engineering.[25] Second, Hugh's account shows that despite our penchant for separating engineering and theology, a theological account of the mechanical arts was possible. This is not to say his account is more persuasive than Davis's, only that engineering need not be excluded from a theological account of human life.

The third conclusion to draw from the *Didascalion* is that, for a careful thinker such as Hugh, a theological account was the only account that was broad enough to encompass all he had learned from Plato (especially the *Timaeus*), Aristotle, Augustine, Boethius, Varro, Quintilian, Isidore, and others. His strategy was to absorb all the pertinent sources into a master theological narrative. We moderns tend to be suspicious of such a methodology. We are more accustomed to reconciling diverse views (if they can be reconciled at all—and it has become increasingly in vogue to assume an incommensurable plurality of views) by reducing all the views to their greatest common denominator. Of course such a reductive methodology means that those tenets distinctive to specific religions such as Christianity or Islam or Judaism must be surrendered in the name of peaceful coexistence with its rivals. But then what is left? The greatest common denominator, it would be argued five centuries later, was the notion of "pure nature." However, this notion was simply not available to Hugh for two reasons.

In the first place, as Henri de Lubac has convincingly argued, the perspective of present-day historiographers may be blurred by three hundred years of (Cartesian) dualism that wrongheadedly presupposes it even makes sense to speak of "pure nature." In this thoroughly secularized vision, notions of "grace," "spirit," "calling," and the "supernatural"—if they have substantive content at all—are concluded to be mere add-ons to a presumably more basic concept: "pure nature." But this could not have been the Christian outlook in its previous fifteen centuries. The creation of human beings in God's image had sweeping ramifications for understanding for what human life was intended. Medieval Christians simply took it for granted that human beings were "destined to live eternally in God, to enter into the inner movement of the Trinitarian life and to bring all creation with [them]."[26] In other words, for medieval believers, "nature was made for the supernatural" and cannot even be conceived, much less explained, without it.[27] The inseparability of natural and supernatural typified the medieval Christianity and is given its most eloquent expression by Augustine who included all creation in the "us" of the famous opening to his *Confessions:* "You have made us for yourself, and our heart is restless until it rests in you."

In the second place, until late in the seventeenth century, "natural philosophy" covered much of the same domain as "Christian theology." It is a colossal misunderstanding to think natural philosophy studied "pure nature" while Christian theology studied a putative "supernatural" realm. On the contrary, both disciplines were overlapping responses to the created world (and it was seen as creation, rather than something else).[28] Historian of science Margaret Osler writes,

> Medieval natural philosophy was conditioned by theological presuppositions, and its conclusions pertained to important theological issues. Discussions of the causes of things, for example, included questions about the cause of the world and revolved around the issues of the divine creation of the world. Discussions of matter and change had implications for the interpretation of the Eucharist. Discussions of the nature of animals and how they differ from humans had direct bearing on questions about the immortality of the human soul.[29]

Osler's words point to the fact that medievals could not separate efficient and material causes from final causes in their explanations. Christian theology and natural philosophy had overlapping domains because in a created world both disciplines had the same final cause (namely, union with the creator God). It is only after the Enlightenment project abandons Aristotle that subsequent moderns are tempted to read mere instrumentalism—efficient causes taken in isolation from final causes—back into medieval thought.[30]

Perhaps an example can make this clearer. The requirement that monks devote themselves to work is widely acknowledged. What is contested today is whether the Benedictine motto, "work is prayer" (*laborare est orare*), originally reflected a sacramental rather than an instrumental view of work. For his part, historian Jacques Le Goff maintains that monks worked hard, intentionally trying to improve their efficiency with machinery (such as the water-powered mill constructed at Saint Ursus at Loches in the sixth century) so as to free up time for the essential thing: *opus Dei*, namely contemplative prayer.[31] In other words, Le Goff can see water mills for saving time but not for worship. Does Le Goff get history wrong?

Le Goff's history is not so much wrong as it is monochromatic. Did water mills save time? Of course. But where Le Goff sees in black and white, Hugh sees in resplendent color. For Hugh, mechanical arts yielded artifacts (and processes) that were inherently sacramental because they rendered visible the end of mechanical reasoning, which in its exercise was simultaneously natural (namely, the alleviation of physical weakness) and supernatural (namely, the journeying toward reunion with divine wisdom).

The strength of Hugh's theological account is that it supplies what nontheological (what Hugh called "worldly") accounts could not as easily do, namely, thick description of the final end toward which all human activity aims. In sum, it was by the "lessons of grace" that Hugh was able to see the physical world under both the aspect of the supernatural and the aspect of the natural. Accordingly he described mechanical arts as guided by a dual end. The supervening supernatural end is this: the exercise of mechanical reasoning is part of the journey toward reunion with God. The subvening natural end is this: mechanical artifacts are for the alleviation of physical weakness that is the consequence of living in a fallen world.

NOTES

Many thanks to Terry Tilley, Therese Lysaught, Aaron James, John Heitmann, and Joe Jacobs for their many helpful comments on an earlier draft of this essay.

1. Michael Davis, *Thinking Like an Engineer* (New York: Oxford University Press, 1998), 10.

2. Ibid.

3. Ton Meijknecht and Hans van Drongelen, "How Is the Spirituality of Engineering Taught or Conveyed?" (paper presented at the Designing Engineering Education: Mudd Design Workshop IV, Claremont, California, July 10–12, 2003).

4. Davis, *Thinking Like an Engineer,* 10.

5. Ibid., 15.

6. Alasdair MacIntyre, *After Virtue: A Study in Moral Theory,* 2nd ed. (Notre Dame, IN: University of Notre Dame Press, 1984).

7. Plutarch, "Marcellus," in *The Lives of the Noble Grecians and Romans* (New York: The Modern Library, 1932), 376.

8. Xenophon, "The Economist of Xenophon," trans. Alexander D. O. Wedderburn and W. Gershom Collingwood, *Bibliotheca Pastorum,* vol. 1 (New York: Burt Franklin, 1971), IV.2, pp. 22–23.

9. Aristotle, *Nicomachean Ethics* 4.2, 1123a, available from the Perseus Digital Library, http://www.perseus.tufts.edu. See also *Eudemian Ethics* 1.4, 1215a, and *Rhetoric* 1.9, 1367a.

10. Aristotle, "Politics," in *The Complete Works of Aristotle,* Bollingen Series, ed. Jonathon Barnes (Princeton, NJ: Princeton University Press, 1984), 8.2, 1337b.

11. The classical quadrivium was comprised of arithmetic, music, geometry, and astronomy, while the trivium was comprised of grammar, rhetoric, and logic.

12. Hugh of St. Victor, *Didascalicon,* trans. and ed. J. Taylor (New York: Columbia University Press, 1961), p. 191, n. 64.

13. Arthur O. Lovejoy, *The Great Chain of Being: A Study of the History on an Idea* (New York: Harper, 1960), 4.

14. Hugh of St. Victor, *Didascalicon,* from the introduction, p. 4.

15. This view was nothing new; the ancient Greeks pointed out that there must be some reason why it is easier to step on a cockroach than to put down a horse, namely, that horses have more inherent worth—are higher on the hierarchy of being—than roaches.

16. Romans 1:25.

17. Romans 8:19–22.

18. Hugh of St. Victor, *Didascalicon* I.1, p. 47.

19. From Hugh's *Epitome Dindimi in philosophiam,* cited in Hugh of St. Victor, *Didascalicon,* 12.

20. Marie-Dominique Chenu, "Arts «Méchaniques» Et Œuvres Serviles," *Revue des sciences philosophiques et théologiques* 29 (1940): 314.

21. "Theatrics" may seem like a stretch to include under mechanical arts, but Hugh made the list seven in number so that it matched the perfection of the seven liberal arts. Besides, under theatrics Hugh envisioned any coordinated activity of a group of people. Not just drama, but marching bands and gymnastics would fit under this heading. Had Hugh lived to see Ford's assembly line, he surely would have treated it as a type of theatrics.

22. Cited in Hugh of St. Victor, *Didascalicon,* from the introduction, p. 35.

23. Quoted in Aage Rydstrom-Poulsen, *The Gracious God: Gratia in Augustine and the Twelfth Century* (Copenhagen: Akademisk Forlag, 2002), 206.

24. Hugh of St. Victor, *Didascalicon,* from the introduction, p. 13.

25. Ironically, Hugh does not mention watermills in the list of technologies he describes, though Paris is not far from St. Ursus monastery at Loches in the Loire Valley, the site of a sixth-century mill. This may only signify that the Parisian Hugh was a city boy who had no firsthand experience with mills.

26. Henri De Lubac, "Internal Causes of the Weakening and Disappearance of the Sense of the Sacred," in *Theology in History* (San Francisco: Ignatius Press, 1996), 230.

27. Ibid., 231.

28. Margaret J. Osler, "Mixing Metaphors: Science and Religion or Natural Philosophy and Theology in Early Modern Europe," *History of Science* 35 (1997): 91.

29. Ibid., 92.

30. MacIntyre, *After Virtue.*

31. Jacques Le Goff, *Time, Work, and Culture in the Middle Ages,* trans. Arthur Goldhammer (Chicago: University of Chicago Press, 1980), 80.