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(*b*. Oizé, Maine, France, 8 September 1588; *d*. Paris, France, 1 September 1648)

natural philosophy, acoustics, music, mechanics, optics, scientific communication.

The sciences have sworn among themselves an inviolable partnership; it is almost impossible to separate them, for they would rather suffer than be torn apart; and if anyone persists in doing so, he gets for his trouble only imperfect and confused fragments. Yet they do not arrive all together, but they hold each other by the hand so that they follow one another in a natural order which it is dangerous to change, because they refuse to enter in any other way where they are called.…[1]

Mersenne's most general contribution to European culture was this vision of the developing community of the sciences. It could be achieved only by the cultivation of the particular:

Philosophy would long ago have reached a high level if our predecessors and fathers had put this into practice; and we would not waste time on the primary difficulties, which appear now as severe as in the first centuries which noticed them. We would have the experience of assured phenomena, which would serve as principles for a solid reasoning; truth would not be so deeply sunken; nature would have taken off most of her envelopes; one would see the marvels she contains in all her individuals.…[1]

These complaints had long been heard, yet "most men are glad to find work done, but few want to apply themselves to it, and many think that this search is useless or ridiculous."[1] He offered his scientific study of music as a particular reparation of a general fault.

Born into a family of laborers, Mersenne entered the new Jesuit *collège* at La Flèche in 1604 and remained there until 1609. After two years of theology at the Sorhonne, in 1611 he joined the Order of Minims and in 1619 returned to Paris to the Minim Convent de I'Annonciade near Place Royale, now Place des Vosges. There he remained, except for brief journeys, until his death in 1648.[2] The Minims recognized that Mersenne could best serve their interests through an apostolate of the intellect. He made his entry upon the European intellectual scene in his earliest publications, with a discussion of ancient and modern science in support of a characteristic theological argument. He aimed to use the certifiable successes of natural science as a demonstration of truth against contemporary errors dangerous to religion and the morals of youth. In his vast and diffuse *Quaestiones in Genesim* (1623) he defended orthodox theology against "atheists, magicians, deists and suchlike,"[3] especially Francesco Giorgio, Telesio, Bruno, Francesco Patrizzi, Campanella, and above all his contemporary Robert Fludd, by attacking atomism and the whole range of Hermetic, Cabalist, and "naturalist" doctrines of occult powers and harmonies and of the Creation. In the same volume he included a special refutation of Giorgio,[4] and he continued his attack on this group in *L'impiété des déistes, athées, et libertins de ce temps* (1624). This attack on magic and the occult in defense of the rationality of nature attracted the attention of Pierre Gassendi, whom he met in 1624 and who became his closest friend.[5]

Mersenne's next work, the *Synopsis mathematica* (1626), was a collection of classical and recent texts on mathematics and mechanics. After that came *La vérité des sciences, contre les sceptiques ou Pyrrhoniens*, a long defense ofihe possibility of true human knowledge against the Pyrrhonic skepticism developed especially by Montaigne. Thus religion and morality had some rational basis. Yet while he stood with Aristotle in arguing that nature was both rational and knowable, he denied that theologians had to be tied to Aristotle.[6] Against the qualitative, verbal Aristotelian physics he came to argue that nature was rational, its actions limited by quantitative laws, because it was a mechanism.[7]

From about 1623 Mersenne began to make the careful selection of *savants* who met at his convent in Paris or corresponded with him from all over Europe and as far afield as Tunisia, Syria, and Constantinople. His regular visitors or correspondents came to include Peirese, Gassendi, Descartes,[8], the Roman musicologist Giovanni Batistta Doni, Roberval, Beeckman, J. B. van Helmont, Fermat, Hobbes, and the Pascals. It was in Mersenne's quarters that in 1647 the young Blaise Pascal first met Descartes.[9] Mersenne's role as secretary of the republic of scientific letters, with a strong point of view of his own, became institutionalized in the Academia Parisiensts, which he organized in 1635.[10] His monument as an architect of the European scientific community is the rich edition of his *Correspondance* published in Paris in the present century.

Mersenne developed his mature natural philosophy in relation to two fundamental questions. The first was the validity in physics of the axiomatic theory of truly scientific demonstration described in Aristotle's *Posterior Analytics* and exemplified in contemporary discussions especially by Euclid's geometry. Mersenne entered in the wake of the sixteenth-century debate on skepticism. The second question was the acceptability of a strictly mechanistic conception of nature. Opinions about these two questions decided what was believed to be discoverable in nature and what any particular inquiry had discovered. Opinions

about the second also decided how to deal with the relationship of perceiver to world perceived, and so with the information communicated, especially through vision and hearing.

Mersenne's approach to these problems represents a persistent style in science. He took up his characteristic position on the first in the course of the debate over the new astronomy. He treated the decree of 1616 against Copernicus with Northern independence and moved in his early writings from rejection of the hypothesis of the earth's motions because sufficient evidence was lacking,[11] to preference for it as the most plausible. Copernicus' hypothesis, he said, had been neither refuted nor demonstrated: "I have never liked the attitude of people who want to look for, or feign, or imagine reasons or demonstrations where there are none; it is better to confess our ignorance than abuse the world".[12] But Mersenne reacted strongly against theologically sensitive extensions of the new cosmology, especially the doctrines of a plurality of worlds and of the infinity of the universe.[13] He took particular exception to Giordano Bruno: "one of the wickedest men whom the earth has ever supported … who seems to have invented a new manner of philosophizing only in order to make underhand attacks on the Christian religion."[14] He maintained that ecclesiastics had the right to condemn opinions likely to scandalize their flocks and merely advised moderation in censorship, because in the end "the true philosophy never conflicts with the belief of the Church."[15]

Through the Christian philosopher defending true knowledge against the skeptic in *La vérité des sciences*, and in later essays, Mersenne defined the kind of rational knowledge he held to be available. He found in Francis Bacon a program for real scientific knowledge, but he reproached him for failing to keep abreast of the "progress of the sciences" and for proposing the impossible goal of penetrating "the nature of things."[16] Only God knew the essences of things. God's inscrutable omnipotence, which denied men independent rational knowledge of his reasons, and the logical impossibility of demonstrating causes uniquely determined by effects reduced the order of nature for men simply to an order of contingent fact. Mersenne concluded that the only knowledge of the physical world available to men was that of the quantitative externals of effects, and that the only hope of science was to explore these externals by means of experiment and the most probable hypotheses. But this was true knowledge, able to guide men's actions, even though theology and logic showed it to be less than that claimed to be possible by Aristotle.[17]

In 1629, after some earlier approaches, Mersenne wrote to Galileo, offering his services in publishing "the new system of the motion of the earth which you have perfected, but which you cannot publish because of the prohibition of the Inquisition."[18] Galileo did not reply to this generous offer—nor, indeed, to any of Mersenne's later letters to him. But Mersenne was not put off. He had come to see in Galileo's work a supreme illustration of the rationality of nature governed by mechanical laws and, so far as these laws went, of the true program for natural science.[19] In 1633 he published his first critique of Galileo's *Dialogo* (1632) in his *Traité des mouvemens et de la cheute des corps pesans et de la proportion de leurs différentes vitesses, dans lequel l'on verra plusieurs expériences trés exactes*.[20] His first response to hearing of Galileo's condemnation in that year was to agree with the need for the Church to preserve Scripture from error;[21] yet he came forward at once with a French version (with additions of his own) of Galileo's unpublished early treatise on mechanics under the title *Les méchaniques de Galilée* (1634), and with a summary account of the first two days of the *Dialogo* and of the trial in *Les questions théologiques,physiques, morales, et mathématiques* (1634).

Mersenne's mature natural philosophy appeared in *Les questions* and three other works in the same year: *Questions ionuyës, Questions harmoniques*, and *Les préludes de l'harnumie universelle*.[22] He made it plain that Galileo had not been condemned for heresy; and although he wrote later that he would not be prepared to risk schism for the new astronomy,[23] in 1634 he planned to write a defense of Galileo.[24] He gave this up. Mersenne disagreed with Galileo's claim to "necessary demonstrations" on the general ground that no physical science had "the force of perfect demonstration;"[25] and like most of his contemporaries he was unconvinced by the dynamical arguments so far produced by Galileo or anyone else. Yet while he saw the question of the earth's motion as undecided, he encouraged the search for fresh quantitative evidence which alone would make it possible "to distinguish the way nature acts in these movements, and to make a decision about it."[26]

Mersenne's conclusion that an inescapable "ignorance of true causes"[27] was imposed by the human situation gave him a scientific style interestingly different from that of Galileo and of Descartes. They aimed at certainty in physical science; Mersenne, disbelieving in the possibility of certainty, aimed at precision. Galileo's lack of precision in his first published mention of his experiments on acceleration down an inclined plane in the *Dialogo* led Mersenne to doubt whether he had really performed them. His own carefully repeated experiments, using a seconds pendulum to measure time, confirmed the "duplicate proportion" between distance and time deduced by Galileo but gave values nearly twice as great for the actual distances fallen. He commented that "one should not rely too much only on reasoning."[28] On many occasions Mersenne's too close attention to the untidy facts of observation may have deprived him of theoretical insight; but his insistence on the careful specification of experimental procedures, repetition of experiments, publication of the numerical results of actual measurements as distinct from those calculated from theory, and recognition of approximations marked a notable step in the organization of experimental science in the seventeenth century. Amid many words and some credulity, the works of his maturity, especially on acoustics and optics, contain models of "expériences bien reglées et bien faites"[29] and of rational appreciation of the limits of measurement and of discovery.

While strict demonstration was beyond natural science, Mersenne maintained that the imitation of God's works in nature by means of technological artifacts gave experimental natural philosophy an opening into possible explanations of phenomena. In this way he linked his experimental method with the second fundamental question for his natural philosophy—the conception of nature as a mechanism—and with the method of the hypothetical model. Characteristically it was through theological issues that he developed the central idea that living things were automatons. He used it as a weapon in his campaign for the

uniqueness of human reason and of its power to grasp true knowledge and moral responsibility, against the false doctrines both of "les naturalistes."[30] who asserted human participation in a world soul, and of the skeptics, who threw doubt on human superiority over the animals. After his visit to Beeckman, Descartes, and J. B. van Helmont in the Netherlands in 1630,[31] Mersenne came to hold that, on the analogy of sound, light was a form of purely corporeal propagation. Although he remained unconvinced by the evidence for any of the current theories of light and sound and changed his views several times, his restriction of the choice to physical motions gave him (like Descartes) a method of asking how these motions affected a sentient being.[32] He disposed finally of the arguments against the uniqueness of man by declaring animals to be simply automatons, explicitly first in *Les préludesde l'harmonie universelle* (1634):

… for the animals, which we resemble and which would be our equals if we did not have reason, do not reflect upon the actions or the passions of their external or internal senses, and do not know what is color, odor or sound, or if there is any difference between these objects, to which they are moved rather than moving themselves there. This comes about by the force of the impression that the different objects make on their organs and on their senses, for they cannot discern if it is more appropriate to go and drink or eat or do something else, and they do not eat or drink or do anything else except when the presence of objects, or the animal imagination [*l'imagination brutalle*], necessitates them and transports them to their objects, without their knowing what they do, whether good or bad; which would happen to us just as to them if we were destitute of reason, for they have no enlightenment except what they must have to take their nourishment and to serve us for the uses to which God has destined them.[33]

So one could say of the animals that they knew nothing of the world impinging upon them, "that they do not so much act as be put into action, and that objects make an impression on their senses such that it is necessary for them to follow it just as it is necessary for the wheels of a clock to follow the weights and the spring that pulls them."[34] Yet Mersenne did not say, like Descartes, that animals were machines identical in kind with the artificial machines made by men. He wrote that the movements of the heart would be understood without mystery if one could discover its mechanism,[35] but men could imitate God's productions in nature only externally and quantitatively. The essence remained hidden. Nevertheless, men's artificial imitations could become testable hypotheses or models for explaining natural phenomena.[36] The quantitative relations within natural phenomena represented the rational and stable *harmonie universelle* that God had chosen to exhibit, both within the structure of his physical creation and in the information about it that men were in a position to discover and communicate.

Mersenne selected for his own particular field of positive inquiry, and for the elimination of magic and the irrational, the mode of operation of vision and of heard sound, and of the languages of men and animals. His first original contributions to acoustics (on vibrating strings), as well as analyses of ancient and modern musical theory and optics, appeared in *Quaestiones in Genesim* (1623). In the same year he announced in his *Observationes*[37] on Francesco Giorgio's plans for a systematic science of sound, "le grand oeuvre de la musique,"[38] which henceforth became his chief intellectual preoccupation. The first sketches appeared in the *Traité de l'harmonie universelle* (1627),[39]*Questions harmoniques* (1634), and *Les préludes de l'harmonie universelle* (1634). Meanwhile, by 1629 Mersenne had planned and soon afterward began writing simultaneously two sets of treatises, in French and in Latin, which together form his great systematic work and were published as the two parts of *Harmonie universelle, contenant la théorie et la pratique de la musique* (1636, 1637), and the eight books of *Harmonicorum libri* with *Harmonicorum instrumentorum libri* IV (1636).[40] Before the final sections of *Harmonie universelle* were in print, he read in Paris, in the winter of 1636–1637,a manuscript of the first day of Galileo's *Discorsi* (1638) containing an account of conclusions about acoustics and the pendulum similar to his own.[41] Mersenne's next work on these subjects was his French summary and critical discussion of Galileo's book in *Les nouvelles pensées de Galilée* (1639). Later he published the results of further acoustical researches in three related works, *Cogitata physico-mathematicae* (1644), *Universae geometriae mixtaeque mathematicae synopsis* (1644), and *Novarum observationum physico-mathematicarum tomus* III (1647). The last contains a summary of his contributions to the science of sound.

Parallel discussions of light and vision, beginning in *Quaestiones in Genesim* and Mersenne's correspondence from this time, run especially through *Harmonie universelle and Harmonicorum libri*, the *Cogitata*, and *Universae geometriae synopsis*. The inclusion in the optical section of *Universae geometriae synopsis* of unpublished work by Walter Warner, and of a version of Hobbes's treatise on optics with its mechanistic psychology, reflects Mersenne's close English connections at this time. His final contributions to optics, including experimental studies of visual acuity and binocular vision and a critical discussion of current hypotheses on the nature of light, appeared posthumously in *L'optique et la catoptrique* (1651).

Mersenne's scientific analysis of sound and of its effects on the ear and the soul began with the fundamental demonstration that pitch is proportional to frequency and hence that the musical intervals (octave, fifth, fourth, and so on) are ratios of frequencies of vibrations, whatever instrument produces them. The essential propositions were established by G. B. Benedetti (*ca*. 1563), Galileo's father, Vincenzio Galilei (1589–1590), Beeckman (1614–1615), and, finally, Mersenne (1623–1634). Mersenne gave an experimental proof by counting the slow vibrations of very long strings against time measured by pulse beats or a seconds pendulum. He then used the laws he had completed (now bearing his name), relating frequency to the length, tension, and specific gravity of strings, to calculate frequencies too rapid to count. Similar relations were established for wind and percussion instruments. The demonstration of these propositions made it possible to offer quantitative physical explanations of consonance, dissonance, and resonance.[42]

An allied outstanding discovery apparently made first by Mersenne was the law that the frequency of a pendulum is inversely proportional to the square root of the length. His first statement of this was printed by 30 June 1634, about a year before Galileo's was written.[43] Exploring further acoustical quantities, Mersenne pioneered the scientific study of the upper and lower

limits of audible frequencies, of harmonics, and of the measurement of the speed of sound, which he showed to be independent of pitch and loudness. He established that the intensity of sound, like that of light, is inversely proportional to the distance from its source.[44] Mersenne's discussions, after his visit to Italy in 1644, of the Italian and later French experiments with a Torricellian vacuum helped to make a live issue of this whole subject and its bearing on the true medium of sound and on the existence of atmospheric pressure.[45] Besides these contributions to science, collaboration with Doni on an ambitious plan for a comprehensive historical work on the theory and practice of ancient and modern music[46] yielded a rich collection of descriptions and illustrations of instruments, making *Harmonie universelle* and its Latin counterpart essential sources for musicology.

In keeping with his empirical philosophy, Mersenne looked for purely rational explanations of the motions and dispositions of the soul brought about by music. He aimed to put an end to all ideas of magical and occult powers of words and sounds.[47] At the same time he offered a rational analysis of language, arguing that if it was language that chiefly distinguished men from animals, this was a fundamental distinction, for language meant conscious understanding of meaning. The speech and jargon of animals was a kind of communication, but not language, for they mindlessly emitted and responded to messages simply as automatons.[48] Mersenne soon rejected any idea that there were natural names revealing the natures of things and firmly proposed a purely rational theory of language that made words simply conventional physical signs. Because all men possessed reason, they had developed languages in which spoken or written words signified meanings. But just as the effects of music varied with temperament, race, period, and culture, so different groups of men had come to express their common understanding of meaning in a variety of languages diversified by their different historical experiences, environments, needs, temperaments, and customs. In this analysis of common elements Mersenne saw a means of inventing a perfect universal language that could convey information without error. Basing his linguistic experiments on a calculus of permutations and combinations, he proposed a system that would convey the only knowledge of things available to men, that of their quantitative externals. Such a language of quantities "could be called natural and universal"[50] and would be a perfect means of philosophical communication.

Descartes's famous comment that this perfect language could be achieved only in an earthly paradise[51] was true in a way perhaps not intended, for "le bon Pére Mersenne" seems to have lived mentally in just such a paradise. "A man of simple, innocent, pure heart, without guile," Gassendi wrote three days after his friend had died in his arms. "A man than whom none was more painstaking, inquiring, experienced. A man whom all the arts and sciences to whose advance he tirelessly devoted himself, by investigating or by deliberating or by stimulating others, will justly mourn."[52] With almost his last breath Mersenne asked for an autopsy to discover the cause of his death. *Maxime de Minimis*.[53] He illustrates the creativeness of gifts of personality distinct from those of sheer originality in the scientific movement.

NOTES

1. Mersenne, *Les préludes de l'harmonie universelle* (Paris, 1634), 135–139.

2. Lenoble, *Mersenne*, 15 ff.

3. Mersenne. *Quaestiones celeberrime in Genesim, cum accurata textus explicatione. In hoc volumine athei, et deistae impugnantur, et expurgantur, et Vulgata editio ab haereticorum calumniis vindicatur. Graecorum et Herbraeorum musica instauratur.… Opus theologis, philosophis, medicis, iuriconsultis, mathematicis, musicis vero, et catoptricis praesertim utile* … (Paris, 1623), preface.

4. Mersenne, *Observationes et emendationes ad Francisci Georgii Veneti problemata* (Paris, 1623).

5. Mersenne, *Correspondance*, I, 190–193; Lenoble, *Mersenne*, xviii, 28.

6.*Quaestiones in Genesim*, preface.

7. Mersenne, *Les méchaniques de Galilée* (1634), "Épistre dédicatoire," ch. 1.

8. It seems likely that he met Descartes in either 1623 or 1625, before or after the latter's journey to Italy: see *Correspondance*, I, 149; and Lenoble, *Mersenne*, 1, 17, 31, 314–316, for the improbability of their friendship at La Fléche as boys separated by seven and a half years in age, and other misconceptions of their relationship promulgated by Descartes's biographer Adrien Bailelt.

9. A. Baillet, *La vie de Monsieur Des-Cartes*, II (1691), 327–328; Jacqueline Pascal's letter of 25 Sept. 1647, in Blaise Pascal, *Oeuvres*, L. Brunschvicg, P. Boutroux, and F. Gazier, eds., II (Paris, 1908), 39–48, Pascal in his "Histoire de la roulette" gave Mersenne the credit for being the first to consider, about 1615, the curve produced by "le roulement des roues": *Oeuvres*, VIII (1914), 195; cf. Mersenne, *Correspondance*, I, 13, 183–184, and II, 598–599.

10.*Correspondance*, I, xliii–xliv, V, 209–211, 371; Lenoble, *Mersenne*, I, 35–36, 48, 233–234, 586–594. Mersenne had for more than a decade been a member of the Cabinet des Fréres Dupuy; for this and the various proposals he made beginning in

1623 for national and international cooperation through academies of theology in which scientific and other experts assisted, of science and mathematics, and of music, see the *Correspondance*, I, 45, 106–107, 129, 136–137, 169–172, V, 301–302; *Quaestiones in Genesim*, preface, dedication, and cols. 1510–1511, 1683–1687; La *vérité des sciences*, 206–224, 751–752, 913–914; *Traité de l'harmonic universelle*, 50, 255–256.

11.*Quaestiones in Genesim*, preface and cols. 841–850, 879–920. He gave considerable attention to Kepler, whom he supported against Fludd: cf. cols. 1016, 1556–1562; *Correspondance*, I, 131–132, 147–148; Lenoble, *Mersenne*, 224–225, 367–370, 394–413.

12.*L'impiété des déistes*, II, 200–201; cf. 198.

13.*Quaestiones in Genesim*, cols. 57, 85, 892–893, 903–904, 1081–1096, 1164; cf. *Correspondance*, I, 130–135.

14.*L'impiété*, I, 230–231; cf. II, 326–342, 363–364, 475.

15.*La vérité*, 111; cf. *L'impiété*, II, 479, 494–495.

16.*La vérité* 109, 212–213; cf. 913–914.

17.*Ibid*., 13–15, 226; *Les questions théologiques* (1634), "Épistre and pp. 9–11, 16–19, 116–117, 123–124, 178–183, 229; *Questions inouyës* (1634), 69–78, 130–131, 153–154; see notes 25–27.

18.*Correspondance*, II, 175.

19. Cf note 7.

20.*Correspondance*, III, 437–439, 561–568, 630–633.

21. Letter of 8 Feb. 1634, *ibid*., IV, 37–38.

22.*Ibid*., IV, 76–78, 150–157; cf. III, 570–572.

23. Mersenne to Martinus Ruarus, 1 Apr. 1644, in Ruarus' *Epistolarum selectarum centuria* (Paris, 1677), 269; Lenoble, *Mersenne*, 413.

24.*Correspondance*, IV, 226, 232, 267–268, 406–407, 411–412. V, 106, 127, 214; note 22, Cf. Descartes's letters to Mersenne during 1633–1635 on Galileo: *ibid*., III, 557–560; IV, 26–29, 50–52, 97–99, 297–300; V, 127.

25.*Les questions théologiques*, 116–117; cf, 18–19,43–44, 164.

26.*Harmonie universelle* (1636), "Traitez de la nature des sons et des mouvemens," I, prop, xxxiii, p. 76; cf. II, props. xix, xxi, pp. 149–150, 154–155. The same attitude appears in the *Cogitata physico-mathematica* (1644), "Hydraulica," 251, 260, and "Ballistica," 81–82; in the *Universae geometriae synopsis* (1644), "Cosmographia," preface, 258; and in Roberval's dedication to his "Arisiarchus," printed in Mersenne's *Novarum observationum tomus* III (1647).

27.*Les questions théologiques*, 18–49; cf, *Harmonie universelle*, "Premiére preface générale" see noies 20, 29.

28.*Harmonie universelle*, "Traitez … des sons," II, prop. vii, coroll. 1, p. 112; cf. prop, i, pp. 85–88, and prop vii, pp, 108–112; and for his seconds pendulum, prop, xv, pp, 135–137, prop, xxii, coroll. 9, p. 220; *Correspondance*, IV, 409–411; A. Koyré, "An Experiment in Measurement." These criticisms may have provoked Galileo to describe his experiment in more detail in the *Discorsi* (1638); Mersenne again repeated the experiment and wrote in *Les nouvelles pensées de Galilée* (1639) that, with a ball heavy enough not to he significantly affected by air resistance, he found "les mesmes proportions" (pp. 188–189).

29.*Harmonie universelle*, "Traitez … des sons," III, prop. v, p. 167; cf. *Novarum observationum … tomus III*, 113, on reason guiding the senses.

30.*Les préludes*, 118; cf. *Quaestiones in Genesim*, cols. 130, 937–948, 1262–1272; *L'impiété*, II, 360–378, 390–391, 401–437; *La vérité*, 15–20, 25–36, 179–189; *Les questions théologiques*, 229–232.

31. See for this visit, *Correspondance*, II, 486, 506–507, 522–525.

32. See for discussions about light and sound, *ibid*., I, 329–330, 333–335, II, 107–108, 116–124, 248–249, 282–283, 293–296, 353, 456–459, 467–477, 669–670, III, 35–42, 48–49; *Quaestiones in Genesim*, cols. 742, 1561, 1892; *La vérité*, 69–72; *Traité*

de l'harmonie universelle, preface and p. 7; *Les questions théologiques*, 67–69, 105–106, and 164 of the expurgated ed. (Lenoble, *Mersenne*, xx, 399–401, 518; *Correspondance*, IV, 74–76, 203–206, 267–271); *Harmonie universelle*, "Traitez de la nature des sons," I, props. i–ii, viii–x, xxv, xxxii, pp. 1–6, 14–19, 44–48, 73–74; *Harmonicorum libri*, I, props, ii–vi, pp. 1–3; *Cogitata physico-mathematica*, "Harmonia," 261–271, "Ballistica," preface and pp. 74–82 (on Hobbes, etc.); *Universae geomatriae … synopsis*, "Praefatio utilis in synopsim *mathematicam*," sec. x, and pp. 471 bis-487, 548, 567–571 (hy Hobbes); *L'optique et la catoptrique* (1651), 1–3. 49–54, 77–92; Lenoble, *Mersenne*, 107–108, 317–318, 370–371, 414–418, 421–424, 478–486; note 44.

33.*Les préludes*, 156–159. Their correspondence and Mersenne's publications leave uncertain what Mersenne knew at this time of the earlier ideas developed by Descartes in the *Regulae*, left unfinished in 1629, and *Le monde* and *L'homme*, begun in the same year.

34.*Harmonic universelle* (1637), "Traitez de la voix," I, prop. lii, p. 79; cf. note 47.

35.*Les questions théologiques*, 76–81; cf. 183. Mersennc sent a copy of William Harvey's *De motu cordis* (1628) together with a set of Fludd's works to Gassendi in Dec. 1628 and discussed the circulation of the blood with Descartes: *Correspondance*, II, 181–182, 189, 268; III, 346, 349–350; VIII, 296.

36.*La vérité*, preface: *Harmonie universelle*, "Traitez de la voix" II, prop. xxii, pp. 159–160, "Nouvelles observations physiques et mathématiques," I, coroll. 5, pp. 7–8.

37. Cols. 439–440; see note 4.

38.*la vérité*, 567; cf. preface and 370–371, 579, 981.

39. "Sommaire" cf. *Correspondance*, I, 195–196, 204.

40. Mersenne created a major bibliographical problem by writing these treatises simultaneously with numerous revisions and repetitions, and by having the different sections printed separately: scarcely any two of the extant copies have the same contents in the same order; cf. Lenoble, *Mersenne*, xxi–xxvi; see note 41.

41. Galileo Galilei, *Opere*, A. Favaro, ed., XVI (Florence, 1905), 524, XVII (1907), 63–64, 80–81; Mersenne, *Correspondance*, VI, 83–84, 241–243, cf. 216, 237; *Harmonie universelle* (1637), "Seconde observation" cf. *Les nouvelles pensées de Galilée* (1639), preface and 66–67, 72, 92, 96–99, 104–105, 109–110; cf. *Correspondance*, VII, 107–109, 317–320; see note 42.

42.*Quaestiones in Genesim*, cols. 1556–1562, 1699, 1710; *La vérité* 370–371, 567, 614–620; *Traité de l'harmonie universelle*, 147–148, 447; *Harmonicorum libri*, I, prop, ii, II, props, vi–viii, xvii–xxi, xxxiii–xxxv, IV, prop xxvii; *Harmonie universelle*: "Traité des instrumens," I, props, v, xii, xvi, III, props, vii, xvii; "Traitez … des sons," I, props, i, vii, xiii, III, props, i, v, vi, xv; "Traitez de la voix," I, prop, lii; "Traitez des consonances," I, props, vi, x, xii, xvii, xviii, xix, xxii, II. prop. x. Mersenne wrote from Paris on 20 Mar. 1634 to Peiresc in Aix-en-Provence that after more than ten years of work he had finished his "grand oeuvre de *l'Harmonie universelle*," of which he sent "1e premier cayer" (*Correspondance*, IV, 81–82). The earliest section in which he gave an extensive analysis of the physical quantities determining the notes and intervals produced by vibrating strings, bells, and pipes, and used this to explain resonance, consonance, and dissonance seems to have been the 'Traitez des consonances," I, "Des consonances," This was in print by 2 Feb. 1635 (Mersenne to Doni, *Correspondance*, V, 40–41). Internal references and the *Correspondance*, IV–V, indicate that he was writing at the same time, during 1634, the "Traité des instrumens" (I–III) and the *Harmonicorum libri* (I–IV);see Crombie, *Galileo* and *Mersenne* (forthcoming).

43. Mersenne published this law first in one of his original additions to *Les méchaniques de Galilée*, 7th addition, p. 77. The "privilége du roy" gives 30 June 1634 as the date on which the printing was completed: cf. Mersenne, *Correspondance*, IV, 76–77, 207–212, and the new ed. of *Les méchaniques* by Rochot (1996). The work was bound with Mersenne's *Les questions théologiues* and presumably sent with that to Doni by way of Peiresc in 1634 (Mersenne to Peiresc, 28 July 1634; Doni to Mersenne, 8 Nov. 1634; *Correspondance*, IV, 267, 384–385, appendix III, 444–455). Élie Diodati sent a copy of *Les méchaniques* from Paris to Galileo on 10 Apr. 1635 (*ibid*., V, 132; cf. VI, 242). For Mersenne's use of this pendulum law, and his possible derivation of it from the law of falling bodies, see also *Harmonicorum libri*, II, props, xxvi–xxix; *Harmonie universelle*, "Traitez des instrumens," I props, xix–xx, "Traitez … des sons," III, "Du mouvement," props, xxi, xxiii. Galileo's correspondence with Fulgenzio Micanzio in Venice between 19 Nov. 1634 and 7 Apr. 1635 (*Opere*, XVI, 163, 177, 193, 200–201, 203, 208 210, 214, 217–233, 236–237, 239–244, 254) indicates that he had not written the last part of the first day of the *Discorsi* (in which he discussed the pendulum and acoustics) by the latter date. His letter of 9 June 1635 to Diodati, saying that he had sent a copy to Giovanni Pieroni, and subsequent correspondence (*Opere*, KM 272 274, 300–304, 359–361) establishes this as the latest date of composition. This copy survives in Biblioteca Nazionalc Centrale. Florence, MS Banco Raro 31; cf. note 40.

44. For these subjects see, respectively, *Harmonie universelle*, Traitez des instrument," I, prop, xix, III, prop, xvii, "Traitez … des sons," III, prop, vi, "Traitez de la voix," ,I prop, lii; *Harmonicorum libri*, II, props, xviii, xxxiii; *Harmonie universelle*,

"Traitez des instrumens," IV, prop, ix, VI, prop, xlii, VII, prop, xviii, "Nouvelles observations," IV; *Harmonicorum instrnmentorum libri IV*, I, prop, xxxiii, III, prop, xxvii; cf. *Quaestiones in Genesim*. col. 1560; *Harmonie universelle*, "Traitez … des sons," I, props, vii, viii, xiii, xvii, xxi, III, prop, xxii, "De l'utilité de l'harmonie," prop, ix; *Novarum observationum … toums* III "Reflectiones physico-mathematicae," ch. 20; *Harmonie universelle*, "Traitez … des sons," I, props, xii, xv, cf props, iii, iv (coroll, 30), and III prop, xxi, coroll. 4; *Harmonicorum libri*, II, prop, xxxix.

45.*Novarum observationum … tomus III*, "Praefatio ad lectorem," "Praefatio secunda," and pp. 84–96, 216–218; cf. de Waard, *l'expérience barométrique*, 117–131; Lenoble, *Mersenne*, xxx, 431–436; Middleton, *The History of the Barometer*, 33–54.

46. Cf. *Correspondance*, III, 395, 512–513, IV, 80, 345, 368, VII, 393–394; G. B. Doni, *Annotazioni sopra il compendio de' generi, e de', modi della musica* (Rome, 1640) 277–280.

47.*Quaestiones in Genesim*, cols. 1619–1624; *La vérité*, 16–17, 32, 69–72; *Les préludes*, 212, 219–222; *Questions harmoniques*, 91–99; *Harmonie universelle*, "Préface générate au lecteur," "Traitez … des sons," I, props, i-ii, "Traitez de la voix," I, "Traitez des consonances," I, prop, xxxiii; *Harmonicorum libri*, I, prop, ii; Lenoble, *Mersenne* 522–531.

48.*Harmonie universelle*, "Traitez de la voix," I, prop. xxxix, pp. 49–52; cf. props. vii-xii, xxxviii; cf. note 33.

49. *Quaestiones in Genesim*, cols. 23–24, 470–471, 702–704, 1197–1202, 1217, 1383–1398, 1692; MS continuation, Bibliothéque Nationale, Paris, MS lat. 17, 262, pp. 511, 536 (Lenoble, *Mersenne*, xiii–xiv, 514–517); *L'impiété*, 167; *La vérité*, 67–76, 544–580; *Traité de l'harmonie universelle*, "Sommaire," item 9; *Questions inouyë*, 95–101, 120–122; *Harmonie universelle*, "Preface générale au lecteur" and "Traitez de la voix," preface, I, II, props. vii–xii; *Harmonicorum libri*, VII; Mersenne's discussions from 1621 to 1640 with Guillaume Bredeau, Descartes, Jean Beaugrand, Peiresc, Gassendi, Comenius, and others are in *Correspondance*, I, 61–63, 102–103; II. 323–329, 374–375; III, 254–262; IV, 329; V, 136–140; VI, 4–6; VII, 447–448; X, 264–274; Lenoble. *Mersenne*, 96–109, 514–521.

50.*Les questions théologiques, quest*, xxxiv, "Peut-on inventer une nouvelle science des sons, qui se nomme psophologie?" p. 158 (expurgated ed.); *Harmonie universelle*, "Traitez … des sons," I, prop. xxiv (language played on a lute), "Traitez de la voix," I, props. xii, xlvii–l (artificial rational languages), "De l'utilité de l'harmonie," prop. ix (symbolic language, acoustical telegraph). Cf. his proposals, for methods of imitating human speech with instruments and for teaching deaf-mutes to speak and communicate: *Harmonie universelle*, "Traitez de la voix," I, props, x–xi. li, "Traitez des instrumens," II, prop. ix; cf. *Correspondance*, III, 354, 358–359, 375, 378, IV, 258–259, 262–263, 280, 289, 294 (1633–1634). On instruments for imitating human speech see "Traitez des instrumens," VI, props, xxxi–xxxii, xxxvi, VII, prop. xxx; *Correspondance*, III, 2–9, 538–553, 578–597, V, 269–272, 293–294, 299–300, 410–415, 478–482 (1631–1635).

51. Descartes to Mersenne, 20 Nov. 1629, in Mersenne, *Correspondance*, II, 323–329; cf, 374–375, IV, 329, 332, V, 134–140, VI, 4, 6.

52. Gassendi to Louis de Valois, 4 Sept. 1648, *Opera*, VI (Lyons, 1658), 291; Lenoble, *Mersenne*, 596, cf. 58; cf. Coste, *Vie*, 13, 99–101; Mersenne, *Correspondance*, I, xxx.

53. Constantijn Huygens, in a poem cited by Thuillier, *Diarium …*, II, 104; cf. Lenoble, *Mersenne*, 597, who also quotes a poem by Hobbes on Mersenne.

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