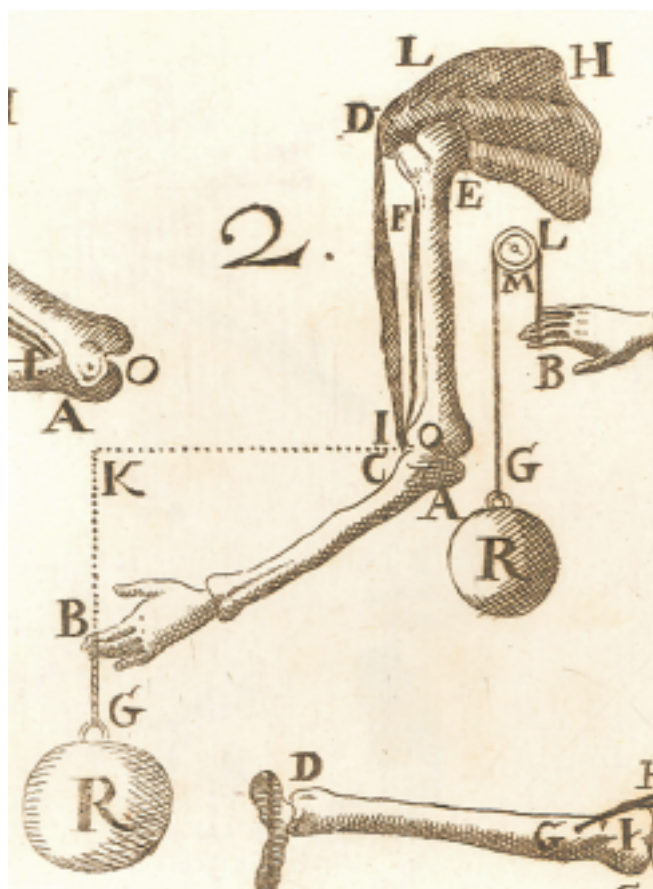
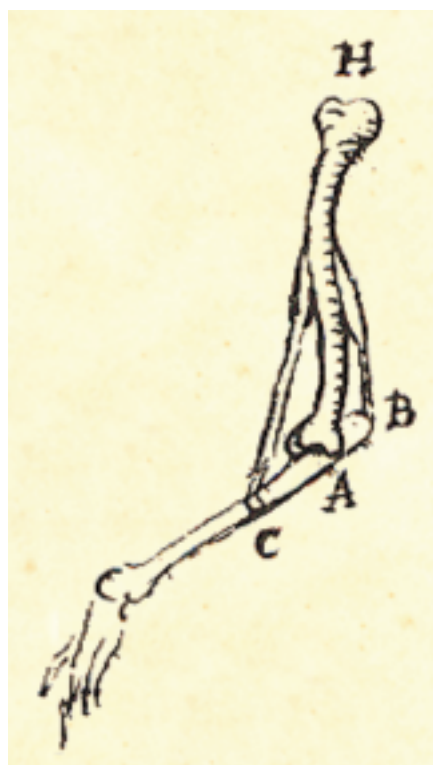
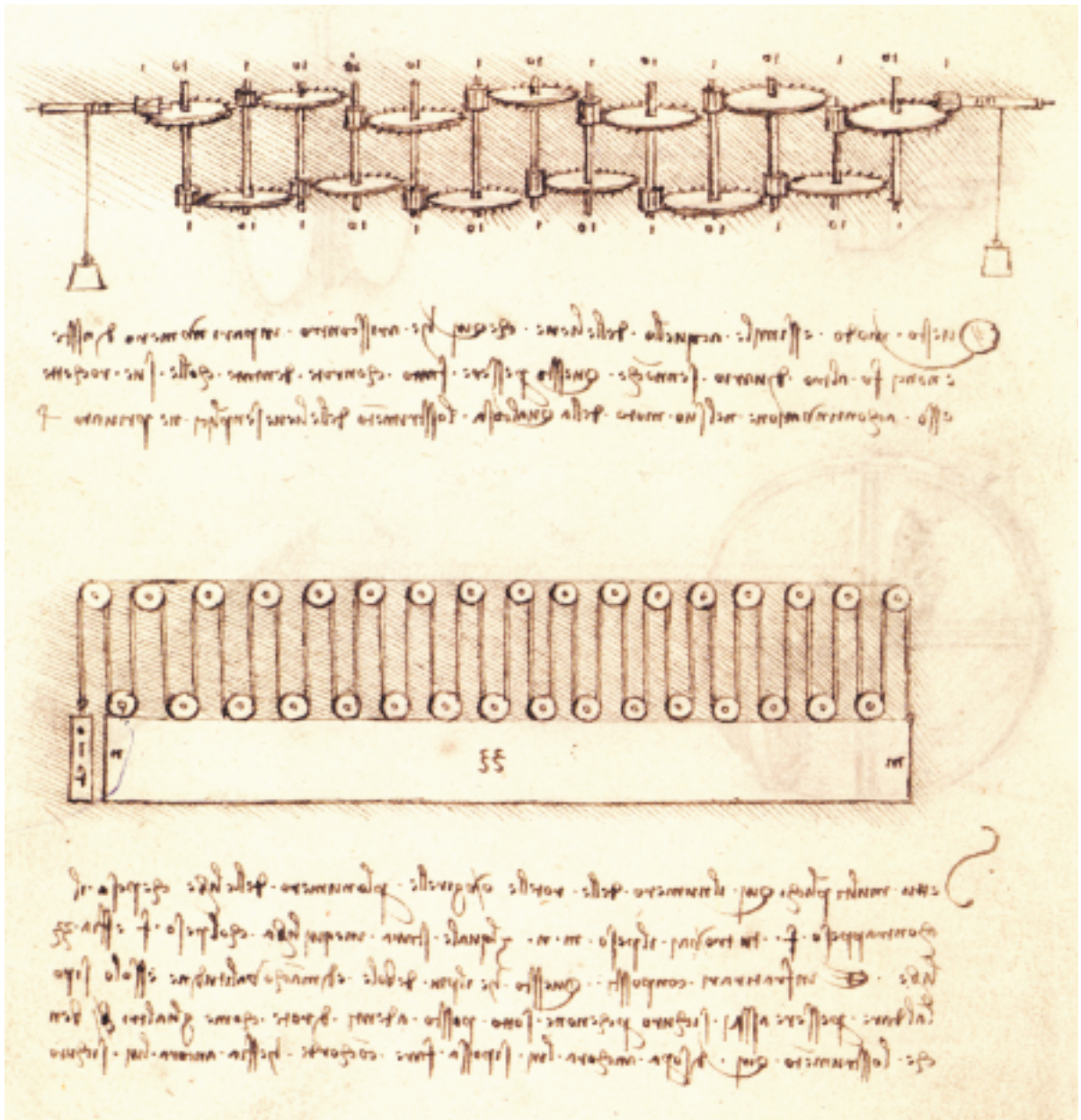


**Fig. 1.9.**  
Borelli reference letters on  
table III, fig. 2, H, C, and A



**Fig. 1.10.**  
Codex Urbinas, f. 120 v





are shown by Roberto Marcolongo in 1939 to find reflections only in Borelli's work of nearly two centuries later.<sup>28</sup> Unfortunately, this interesting pointer was not followed-up by Arturo Uccelli (1940) in his monumental edition of those studies.<sup>29</sup>

Of the eighteen plates in Borelli's *De motu animalium*, almost every one offers a figure that is similar in theme or style to Leonardo's. This is the case not only with drawings; coincidentally, several reference letters match. For example, the Borelli reference letters on plate III, fig. 2, H, C, and A (Fig. 1.9) match those of Codex Urbinas, f. 120 v (Fig. 1.10). Interestingly, Borelli appears to follow the sequence of illustrations in Madrid MS I: he starts with a figure that has elements in common with the page

Fig. 1.11. Madrid MS I, f. 36 r

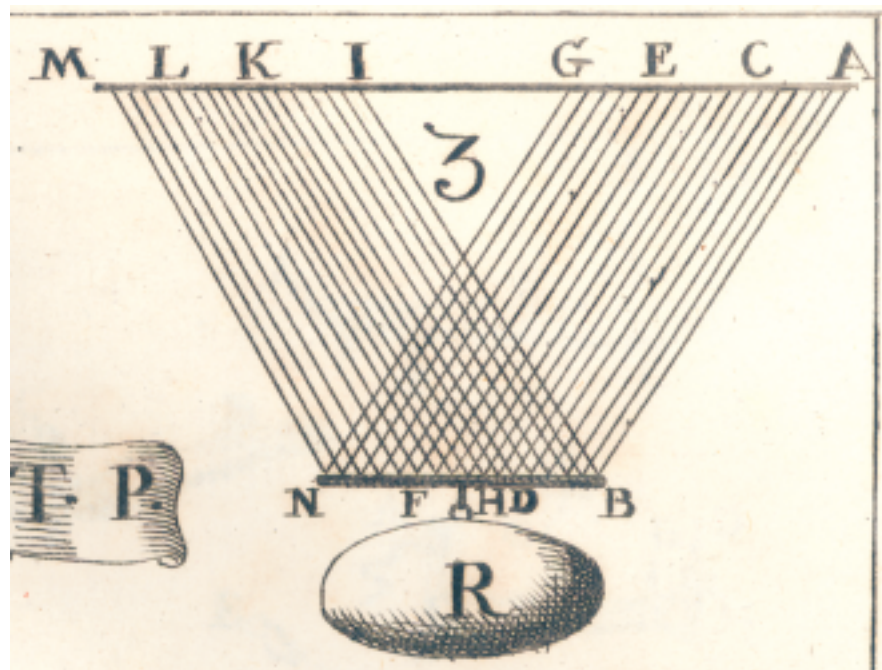
<sup>28</sup> Roberto Marcolongo, *Leonardo artista-scienziato*, Milan, Hoepli, 1939, pp. 197 and 294.

<sup>29</sup> Leonardo da Vinci, *I libri di meccanica nella ricostruzione ordinate da Arturo Uccelli*, Hoepli, Milan, 1940.

**Fig. 1.12.**  
Borelli's table I, fig. 1

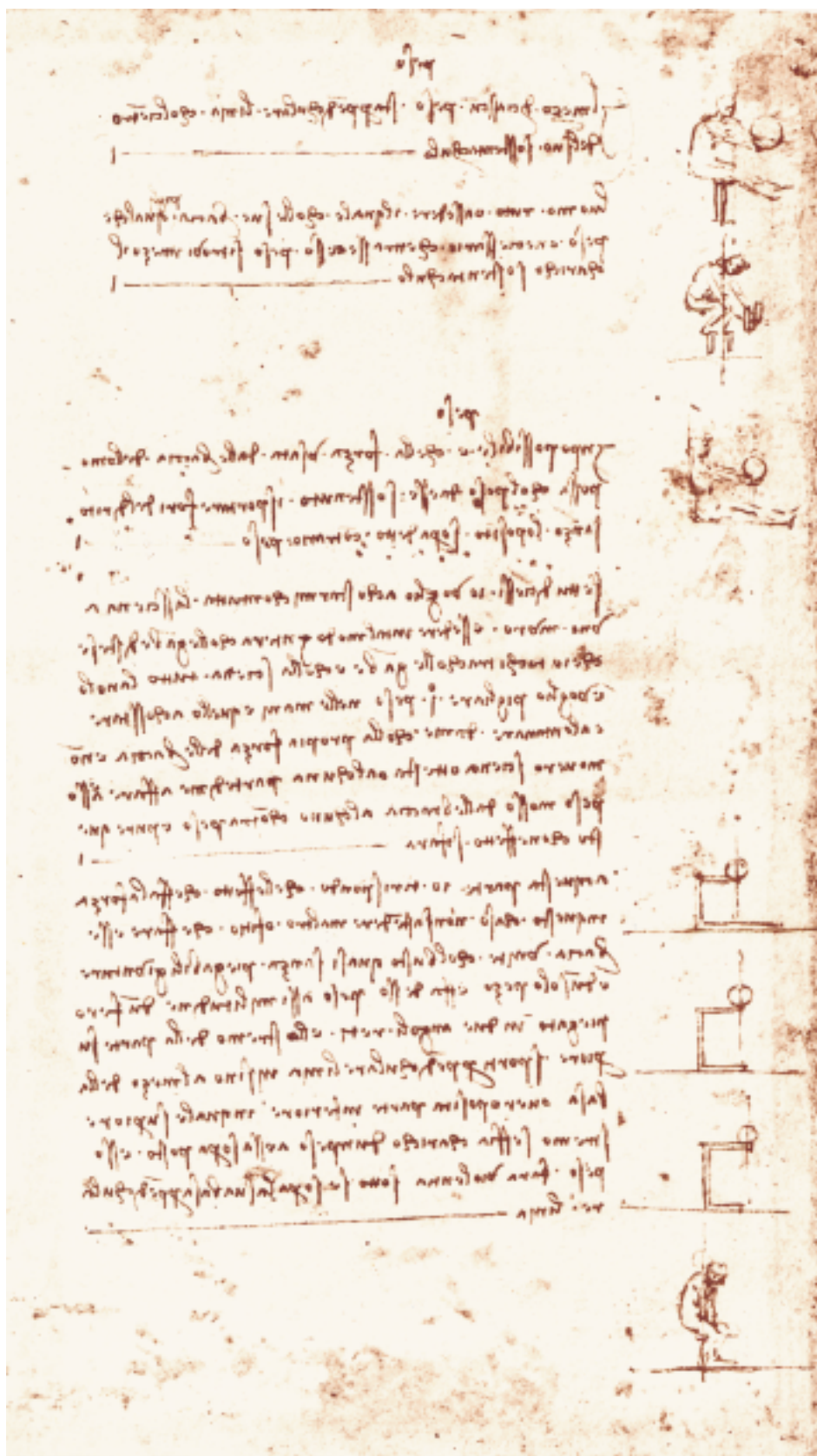


**Fig. 1.13.**  
Borelli's table I, fig. 3



before the first section of missing pages in Madrid MS I. On Madrid MS I, f. 36 r (Fig. 1.11), Leonardo shows a block-and-tackle design with seventeen pulleys the same number as the number of muscle fibers in Borelli's first illustration on plate I, fig. 1 (Fig. 1.12). Plate I, fig. 3 (Fig. 1.13), has thirtyfour muscle fibers the same as the number of cable convolutions in Madrid MS I, f. 36 r. Indeed, the number seventeen shows up throughout the machine design folios of Madrid MS I in the number of pulleys and gear teeth. Is Leonardo trying to tell us something? Is he carefully maintaining analogs to his lost human muscle diagrams?

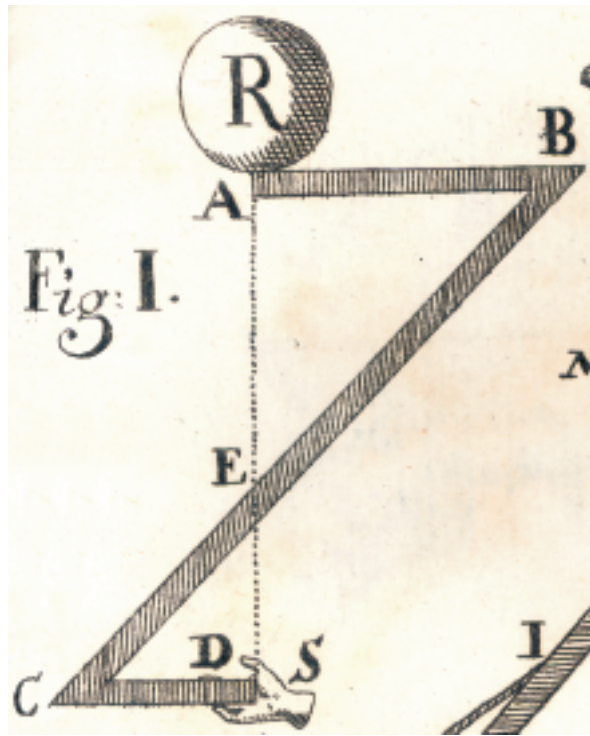




**Fig. 1.14.**  
CA, f. 349 r-b [966 r].  
Studies of forces

Leonardo's biomechanics can be interpreted through the comparative study of Borelli. Because of the great similarity of theme and organization, Borelli may have used it as an aid in interpreting drawings such as CA, f. 966 r [349 r-b] (Fig. 1.14), which represent the human body schematically, and are similar to the diagrams in Borelli's plate V, fig. 1 (Fig. 1.15). Madrid MS I, f. 90 r-v (Fig. 1.16) bears a striking resemblance to Borelli's plate V, fig. 6 (Fig. 1.17). This relates to the leg's lifting capacity

**Fig. 1.15.**  
Borelli's table V, fig. 1



**Fig. 1.16.**  
Madrid MS I, f. 90 r-v. Leg study

**Fig. 1.17.**  
Borelli's table V, fig. 6

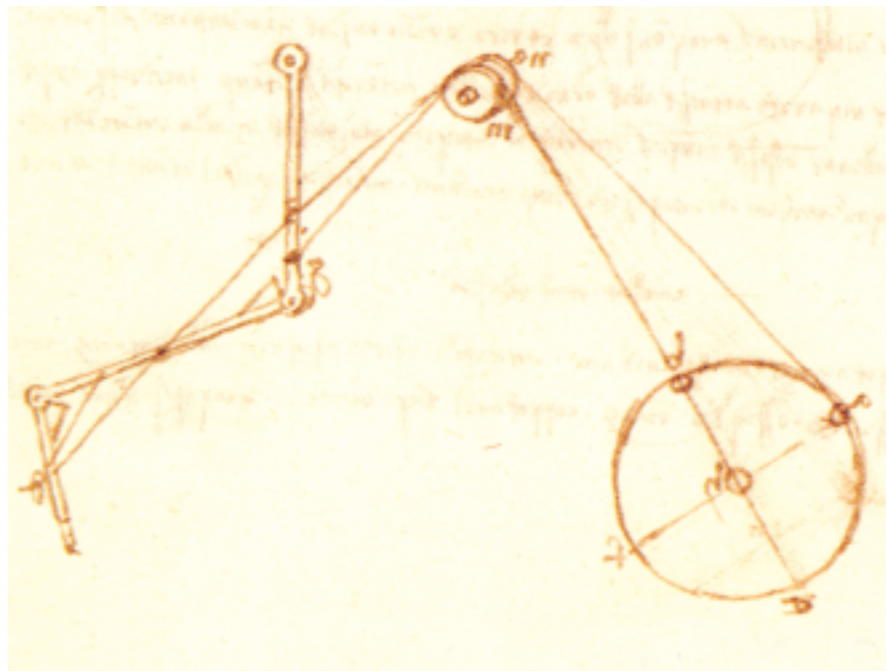
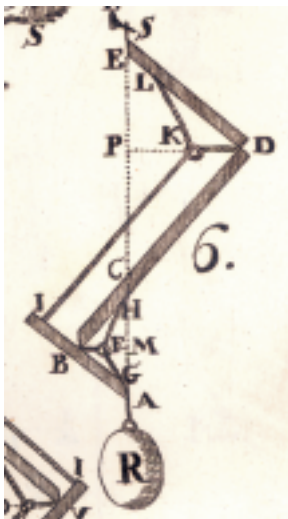




Fig. 1.18. Borelli's table XII, fig. 4

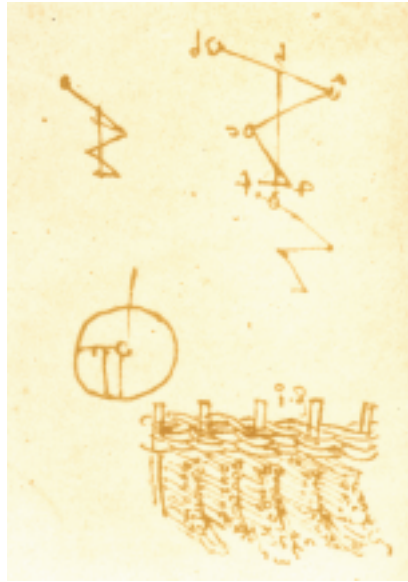


Fig. 1.19. Leonardo's MS L, f. 28 v

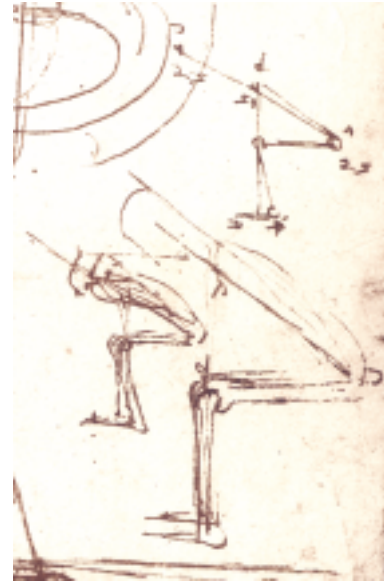


Fig. 1.20. CA, f. 164 r-a [444 r]

in retraction. Also in Borelli's plate XII, fig. 4 (Fig. 1.18), we see a graphic similarity to Leonardo's MS L, f. 28 v (Fig. 1.19), and CA, f. 164 r-a [444 r] (Fig. 1.20), showing a centerline through the body's limbs. In Paris MS L and CA, f. 164 r-a [444 r], are comparable diagrams of the forces involved in pulling a weight uphill which show a leg extending and retracting. This notation may date from 1497–1500. See Chapter III for Leonardo's Robot Knight's leg which may be the practical demonstrate piece based directly on these theoretical studies.

The seed of Leonardo's biomechanics was to come to full fruition nearly two centuries later with Giovanni Borelli's *De motu animalium*. Zubov appropriately refers to Leonardo as Borelli's "spiritual father."<sup>30</sup> Curiously, Pierre Duhem, a fervent advocate of the theory that much of Leonardo's legacy was indeed available and taken advantage of, by his successors, never mentions Borelli.<sup>31</sup> That Borelli learned from Leonardo may never be proved. But it seemed too much of a coincidence that his approach to biomechanics should be so strikingly similar to Leonardo's.

Rushing to my phone, I called Carlo Pedretti in the evening, and excitedly explained my theory.

<sup>30</sup> Zubov, op. cit. (as in note 18 above), p. 184.

<sup>31</sup> Pierre Duhem, *Études sur Leonard de Vinci. Ceux qu'il a lus et ceux qui l'ont lu*, Paris, A. Hermann, 1906, 1909 and 1913, 3 vols.



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