Foster on Descartes's physiology:

But [Descartes] was neither an anatomist nor a physiologist; he studied both anatomy and physiology, but not as an inquirer. He approached these matters as an amateur, but as an amateur having a special purpose, as one desirous to construct out of the current knowledge of the time a physiological basis for his philosophical views.

It was part of his philosophy to shew that man consisted of an earthly machine (machine de terre) inhabited and governed by a rational soul (âme raisonnable); and under the title of 'Man,' L'Homme (1662) he wrote a treatise of physiology, not, as I have said, as a contribution to physiological knowledge, but as a popular exposition of the features of the earthly machine in illustration of its relations to the rational soul. The work thus stands as the first Text-Book of Physiology, written after the modern fashion, though in a popular way....

But Descartes had ... distinctly in view ... the object of popular exposition, and he had especially in view the exposition of the mode of action of the soul. Thus though he begins with the beginning, namely with the ingestion of food, he hurries over digestion and also over the circulation. He was acquainted with Harvey's work, but he had not been convinced by Harvey's arguments; he was not familiar enough with the details of physiological inquiry to feel the full force of Harvey's reasonings. [p. 58]

... Descartes was not a physiological inquirer. His method in physiology was not that of Harvey, not that which since Harvey's time has continued to bring in a rich harvest of discovered truth, not that of working one's way by careful observation, and patient experiment or trial, out of exactly determined anatomical facts, up to the real meaning of the facts. He had a special purpose in view, and with that in view took a freer, wider sweep. He had to shew that the new views which were making it clear in so surprising a way that the universe was a machine working in accordance with physical laws, might be applied also to man; that man, that is to say the body of man, might also be regarded as a machine working in accordance with physical laws. He had to shew this with the help of the knowledge of the time, and he achieved this by picking out such parts of the anatomical discoveries of the age as suited his purpose, and by weaving these together with many other statements, for which he gives no authority and which he yet treats as accredited truths, into a theory of the constitution and action of the nervous system viewed as a mere machine.

... he utilized the doctrine of the animal spirits to explain the phenomena of sensation and movement. For him, the animal spirits constituted a fluid, a very subtle
Descartes' contemporaries stumbled, as we now stumble, at those parts of the basis of his views for which they could find no authority given by anatomical observation or by physiological experiment. Hence his views on the nature of man found no place in the physiology of the day, they passed over wholly into philosophy so called. But his main idea, that the problems of man ought to be treated in the same way as the problems of the rest of nature, made itself felt and produced effects in after times.

I cannot do better than quote the words of a remarkable contemporary of his, Nicolaus Stensen [Steno], who in a discourse delivered in Paris [probably in 1662] on the anatomy of the brain thus sums up Descartes' position as a physiologist.

"Descartes," says he, "was too clever in exposing the errors of current treatises on man to be willing to undertake the task of expounding the true structure of man. Therefore in his essay on Man he does not attempt such a delineation, but is content to describe a machine capable of performing all the functions of which man is capable. And in this sense we may affirm without exaggeration that Descartes bears the palm over all other philosophers in this matter. For he was the first who dared to explain all the functions of man, and especially of the brain, in a mechanical manner. Other authors describe man; Descartes puts before us merely a machine, but by means of this he very clearly exposed the ignorance of others who have treated of man, and opened up for us a way by which to investigate the use of other parts of the body, though it may be difficult to do so with the same clearness and fidelity with which he proceeds in demonstrating the parts of his machine of man, a task which no man before him attempted." [p. 62]

**An example of Borelli's highly developed mechanistic approach, from De motu animalium [On animal motion] (1680) on the causes of muscular contraction:**

Since all muscles, with some few exceptions, do not manifest vital movement otherwise than in obedience to the will, since the commands of the will are not transmitted form the brain which is the instrument of the sensitive, and the seat of the motive soul, by any other channels than the nerves as all confess and as the most decided experiments shew, and since the action of any incorporeal agency or of spirituous gases must be rejected, it is clear that some corporeal substance must be transmitted along the nerves to the muscles or else some commotion must be communicated along some substance in the nerves, in such a way that a very powerful inflation can be brought about in the twinkling of an eye.

And since the inflation, hardening, and contraction do not take place in the channels which serve for bringing them about and in which the motor influence resides, namely, in the nerves themselves, but takes place outside the nerves, namely, in the muscles, it is evident that the substance or the influence which the nerves transmit is not taken by itself alone sufficient to bring about that inflation. It is necessary, therefore, that something else must be added, something which is to be found in the muscles themselves; or that in the
muscles there is some adequate disposition of material so that on the arrival of the influence transmitted by the nerves there takes place something like a fermentation or ebullition, by which the sudden inflation of the muscle is brought about. That such an action is possible is rendered clear by innumerable experiments which are continually being made in chemical elaborations as when spirits of vitriol [sulfuric acid] are poured on oil of tartar; indeed all acid spirits when mixed with fixed salts, at once boil up with a sudden fermentation. In like manner therefore, we may suppose that there takes place in a muscle a somewhat similar mixing from which a sudden fermentation and ebullition results, with the mass of which the porosities of the muscle are filled up and enlarged, thus bringing about the turgescence and the inflation. [in Foster, pp. 74-75]

**Borelli on the mechanical elasticity of the arteries and steady arterial flow into the capillaries:**

In the first place we must disprove the common assertion [by Descartes] that blood is driven through the terminal orifices of the arteries after the fashion of a fountain, simply by the propulsive force of the heart.

The arteries are soft, distensible tubes full of blood, but as we have shewn not filled to extreme distension; and during each beat of the heart there is driven into them by the constriction of the heart, acting like a piston, a mass of blood sufficient to complete their distension or even more than sufficient, in which case the surplus is discharged beyond the arteries by the beat of the heart itself. But so soon as the beat is over the arteries return from their distended condition to the same soft and shrunken state in which they were before the beat. Therefore there must have escaped from them the mass of blood or the surplus of that mass which had been driven into them by the piston of the heart. But the blood which has been driven into the arteries cannot issue from them of its own accord through the extremely minute terminal orifices of the arteries since it possesses no force of its own. Nor is it driven out by the propulsion of the piston of the heart or only partly so since the arteries are not rigid tubes made of steel but are soft, and the force of the heart in its direct action is spent in expanding them, which expansion acts as a cause of retention rather than of expulsion of the blood.

Two effects follow the beat of the heart, the filling of the arteries with the blood driven into them, and the exit of the same blood from the same arteries. Certainly these two events cannot take place at the same time; for the one consists of an expansion, the other in a constriction of the same arteries, and these two being opposed in nature cannot take place at the same time. Whence it must be that the filling of the arteries takes place first, and that their constriction and emptying follows afterwards.

The filling and distention however which takes place first cannot be carried out without a violent extension of the transverse fibres of the said arteries. Now we know from other sources that all fibres of vessels, and all fibres of muscles, of the intestines, of tendons, of membrane, and of the true skin resist extension, and when extended possess a power of contracting like that of a strung bow. Nay, indeed, we see that all fibres when placed in their natural surroundings possess some amount of active tension, for when they are divided they contract of their own accord and become shorter. This would not happen
if these fibres existed in a condition of equilibrium between extension and contraction; like the cord of an unstrung bow they would suffer neither contraction nor extension.

But if all fibres in a natural condition undergo some amount of extension it follows that, when the arteries are filled with blood, the transverse fibres, owing to the enlargement of the cavity, must become much more elongated and in consequence undergo a much greater extension. And since the said expansion of the arteries is succeeded by a constriction which cannot take place without a shortening of the circular fibres, and indeed such a shortening is proper to and part of the very nature of these fibres, it follows that the arteries after their violent expansion, due to their being filled to distension, cannot do other than exercise by the law of nature that mechanical force which they possess. This squeezing the arteries like a rope twisted circularly round them expels with force the blood through their terminal orifices. [in Foster, pp. 78-79]

Borelli on the heart-beat, by muscular contraction identical with the movement of a limb, but differing in ultimate cause; the limb moves by the direct action of the will but the movement of the heart:

. . . may arise by organic necessity, the heart may move as certain automata move. Or possibly the movement may come from a voluntary effort of which we have ceased to be conscious because it has been repeated so often and so constantly.

Borelli thought that all phenomena of glandular secretion could be explained in a mechanical manner by hypotheses on the size and shape of the secreted particles and glandular orifices:

For we have shewn that the fluidity of a liquid cannot be conceived of without its mass being actually divisible into very minute hard and consistent particles of a definite shape, united together not by firm bonds but by simple contact, so that some of them can be agitated, can flow, can move about while others are at rest or are moving in another direction. In no other way can be preserved that fluidity through which fluid parts flow along, mix and fuse together.

Moreover it cannot be doubted that the different natures and properties of fluids depend on the different consistency, structure, configuration and motion of the molecules composing the fluids. Thus the molecules composing water are all homogeneous and like each other but different from those composing oil or a fluid of another nature, and indeed it is agreed that the particles of the said fluids differ in structure, size and shape.

And indeed if the molecules of two heterogeneous fluids were equally mobile so that they could be mixed by simple contact, then a mixture of them, a mixture for instance of oil and water, might be compared to a mixed heap of millet and barley. And since we see that these can be separated by a sieve, so in like manner water and oil are able to pass through the pores of skin and of wood but air cannot, while mercury can pass through the pores of gold but water, oil or air cannot. Consequently the said fluids can be separated (just as vegetable grains may be) from other different fluids with which they may be mixed by means of a sieve of an appropriate structure without any fermentation; for just
as grains pass through a sieve uninjured, so oil and water can pass through the pores of skin or wood, intact, without any change. Wherefore it must be confessed that it follows by mechanical laws that the reason why fluids of the one kind do pass through and those of another kind do not is without doubt because the shapes of the molecules of the said fluids match and are fitted to the shapes of the minute pores through which they are able to pass while the particles of another fluid, since their shapes do not match, are excluded.

Who then would wish to think that the particles of the blood are picked out, separated from the watery particles of the urine and placed in separate receptacles by some magnetic virtue or by some ferment, acting like a servant possessing eyes? Certainly unless we wish to lay hold of follies and wonders we are bound to confess that in the kidneys there exist two kinds of orifices after the manner of two sieves, namely, one a venous one, which by reason of its adjusted configuration receives the particles of blood only, not those of the watery urine, and another, the proper vessels of the kidneys, the shapes of which are fitted for absorbing the particles of water but not the particles of the blood. [in Foster, pp. 81-82]