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Galileo
Il Saggiatore (The Assayer)
(Matthews, 53-61)

I think that tastes, odours, colours, etc., are nothing but mere names for something [that] resides exclusively in our sensitive body, so that if perceiving creatures were removed, all of these qualities would be annihilated and abolished from existence. But just because we have given special names to these qualities, different from the names we have given to the primary and real properties, we are tempted into believing that the former really and truly exist as well as the latter.

- Galileo
"The Assayer"

The bodies that we see around us can be considered to have three kinds of qualities: spatial qualities, like shape, size, and motion; powers, like weight, solidity, magnetism, charge, hardness, and elasticity, and sensible qualities, like colour, heat, and cold. Spatial qualities have to do with how a body fills space, powers with how it acts when moved, hit, compressed, or placed in the vicinity of other bodies, and sensible qualities with those features that are picked up by our specific sense organs.

In describing the mechanical philosophy, Boyle had characterized it as the view that all change in nature results from just the spatial properties of things, that is, from the communication of motion upon impact and the resulting rearrangement of shaped and moving particles in bodies. His list of the mechanical qualities of the bodies is a list just of their spatial qualities. He wanted to show that the powers of bodies are not actually distinct and special properties. Since the powers have to do with how things move or resist motion, and all motion or resistance to motion is supposed to be a result of impact and the corpuscular structure of bodies, he wanted to account for them in those terms. He wanted at all costs to deny that the powers of bodies reflect forms or qualities inhering in and characteristic of specifically different kinds of material, that is, that weight is due to a quality of massiveness that inheres to a greater or lesser extent in different kinds of material, that there is one kind of material that is characteristically solid, another kind that is characteristically compressible, one kind that is characteristically hard, other kinds that are characteristically fluid, brittle or viscous, one kind that is characteristically elastic, another kind that is characteristically malleable, and so on. Boyle and other mechanical philosophers viewed weight, solidity, hardness, elasticity, viscosity, ductility, etc., as nothing more than names for hidden, magically operating causes of change in nature that had not yet been successfully reduced to effects of motion and collision. Accordingly, an important (but also very challenging) part of the mechanist program was to come up with mechanical explanations for all of the different powers.

However, powers are not the only properties of bodies. Bodies also have sensible qualities. Boyle's claim that all change in nature results just from the mechanical properties of bodies did not explicitly rule out the possibility that bodies might also have sensible qualities. But it is a consequence of the mechanist position, which takes all change in nature to be due to the mechanical and hence the exclusively spatial qualities of bodies, that even if bodies do have sensible qualities, those qualities would not play any causal role in nature. And that in turn means that they ought not to have any causal role to play in sensation or perception, since sensation and perception are also natural occurrences. If all change in nature is a result of the mechanical properties, then what causes our sensations of colour, taste, heat and cold, and so on would consistently have to be the motion and impact of particles on our sense organs, not some sensible form of colour, taste, heat or cold existing in the object and somehow imprinting itself on our minds.

But this would suggest that the sensible qualities exist only in us, when we sense them, and that the only qualities that there are in bodies are the spatial ones. If sensible qualities have no role to play in nature, not even in accounting for what causes us to perceive those qualities, then it is extravagant to suppose that they exist outside of us in bodies, doing nothing, as opposed to existing only in us, when they are perceived by us. This is the proposal that was made by Galileo, an earlier proponent of the mechanical philosophy.

QUESTIONS ON THE READING

1. What is heat generally believed to be?
2. According to Galileo there are some properties that it is impossible to conceive a body not having. What are these properties?
3. What is the basis for our belief that bodies have such properties as being red or white, bitter or sweet?
4. How could a body possibly have shape but no colour?
5. What significance did Galileo attach to the fact that a body tickles more under the nose than on the back?

   Reading Note: "he would be gravely in error who would assert that the hand, in addition to movement and contact, intrinsically possesses another and different faculty which we might call the 'tickling faculty'," Galileo's point would be clearer had his Italian been translated as: "intrinsically possesses another and different quality which we might call the 'tickly quality'." He is trying to say that the tickly feeling is not a quality in the thing, but a sensation in the perceiver.
6. What determines whether our tactile sensations will be pleasant or unpleasant?
7. What is the cause of variations in taste?
8. What excites tastes, sounds, and odours?
9. What accounts for the operation of fire?
10. Is it right to say that fire is hot, i.e., that heat exists in fire?

    Reading Note: "Calcified stone" is the product one obtains from burning limestone in a cement kiln. When immersed in water it produces a surprising degree of heat. Today we know that this is because of a chemical reaction between the water and the calcium oxides in the "stone." Galileo thought it was instead somehow due to motion of fire particles trapped in the pores of the stone.
11. Why did Galileo think that a bellows increases the heat of a fire?

12. Did Galileo think that matter is infinitely divisible (i.e., that you can in principle go on dividing a piece of matter in halves forever)?

NOTES ON THE READING

At the outset of the reading Galileo stated that his purpose was to explain what he believed about the causes of heat. But before he did this he proposed to say something about the nature of heat itself. He suspected that heat is not a quality that actually inheres in those bodies that we call hot. Things like fire and lava are not really hot; rather heat is merely something that exists in us when we touch these things. Furthermore, he suspected that this is not just true of heat but of a number of other supposed qualities of bodies as well.

It is instructive that Galileo did not simply deny that heat or the other qualities he went on to discuss are in bodies. Instead, he only claimed to "suspect" or "think" that this is "probably" so. This suggests that he was not capable of proving his point. Like Boyle, he contented himself with establishing the possibility of his view, and with showing that it has certain advantages that make it worth adopting as a working hypothesis or at least worth investigating further.

To this end, Galileo first observed that, were it not for the fact that our senses show them to us, nothing would lead us to infer that bodies possess sensible qualities like colour, smell, or taste. Nothing, in other words, compels us to suppose that bodies must possess these qualities, and could not continue to exist without them.

Of course, simply because a body does not have to have a quality it does not follow that it might not have it anyway. No bodies have to be triangular, either, but that is no reason to suppose that triangles do not exist, especially if we have independent evidence that they do exist. If, for instance, I go for a walk in the forest and see a tree trunk that has been split down the middle by a lightening bolt, I might consider this to be evidence that the lightening is made of triangular or axe-head shaped particles.

But we do not have any such independent evidence that bodies have colours, taste, or smell. We might think that we do because we sense colours, tastes, and smells. But we have to be careful about this. Our senses do not actually tell us that colours, tastes, and smells exist as qualities in bodies. They only tell us that certain colours, tastes, and smells come to exist in us when we are in their presence. I feel the heat of a fire in my skin, hear sounds ringing in my ears, and experience tastes and smells in my mouth and nose. The greatest problem is with the case of colour, which can seem to be outside of me on the surfaces of bodies, though even in that case the experience of variations in colour of the same object with changes in the light or of visual after-images ought to lead us to wonder whether we are really perceiving a quality of the object or instead of something more proximate, such as a quality of the light or of the sensory state produced in us by the light. What Galileo had to say on this point is telling. "Were they not escorted by our physical senses," he wrote, "perhaps neither reason nor understanding would ever, by themselves, arrive at such notions." If triangles or holes exist in nature, then I could find some reason to suppose that they exist other than the fact that I sense them. For instance, I might sense something else that would have to be produced by triangular or perforated objects, such as split wood or beads of sweat on the surface of my skin. But if the only reason I can find to suppose that bodies have colours, tastes, and smells is that I sense these things — so that the only things that qualities of colour, taste, and smell do in nature is give me my sensations of colour, taste and smell — then I might as well just suppose that the colours, tastes, and smells only exist in me and are caused by some different, more generally operative qualities in bodies.

Galileo proceeded to offer an illustration of what he meant to suggest. We all accept that certain tactile sensations, like those of tickles or pinches, exist only in us. This is evident from the fact that we can immediately observe that what produces these sensations is the motion of another body over certain regions of the skin. We do not think that the body that tickles us tickles because it has a form or quality of ticklishness. We rather think that it moves and that it tickles because we, not it, are ticklish (that is, susceptible to experiencing that feeling when bodies move over our skin in a certain way). This is made all the more evident by the fact that we are not equally ticklish on all parts of our bodies, even though the tickling body moves and touches them all in the same way. So it would seem that the tickle exists only in us. It is aroused in us by the motion of bodies over the more sensitive parts of our skin, not transferred to us because the body that touches us itself contains a tickle.

Galileo wanted to suggest that all of the other sensible qualities, and that heat and cold likewise, are like tickles. Rather than be transferred into us from out of bodies that themselves contain those qualities, they are effects of something altogether different in bodies: their shape and motion.

Over the next few pages, Galileo proceeded to sketch a theory of how this might be the case. He claimed that all our tactile sensations could be effects of bodies moving over or pressing against our skin, that smells might be produced by volatile particles rising into the nose and hitting its parts, that tastes might be produced by moist particles mixing with the saliva on the tongue, and that sounds might be produced by percussion that causes undulations in the air that are transmitted into the ears.

But why should we believe any of this? Galileo tried to make the theory attractive by drawing an analogy between it and the Aristotelian doctrine of the elements (touch is supposed to be caused by the element of earth, smell by fire, taste by water, sound by air, and colour, which he hesitated to discuss, by the fifth, celestial element, aether or light), but anyone impressed with Bacon's condemnation of idols of the tribe should not be persuaded by such considerations. Moreover, Galileo himself was explicit that the theory is merely speculative. (He said, for example, that "perhaps" smell is produced by fiery particles.) And the bare fact that it is possible that all the sensible qualities might be produced in us in the same way that tickles are does not suffice to prove that this is in fact the case.

Galileo's theory does have an attractive feature, however. It explains why our noses are higher on our faces and our tongues lower down (the nose is higher to receive the fiery particles that rise up from the food, the tongue lower down to receive the watery particles that descend). Though a Baconian would call this just another idol of the tribe, if a theory that was invented for a quite different purpose is able to explain some other, previously unaccountable or arbitrary fact, that is a mark in its favour.

When Galileo turned to discuss heat he was able to do more of this.

Galileo speculated that the cause of our sensations of heat is a combination of two circumstances: the presence of caloric particles, which he called "ignicoli," that are very small and very sharp, like tiny needles or daggers, and the acceleration of these particles to a high speed. When the ignicoli are set in motion they penetrate our bodies and produce either an agreeable sensation of warmth (if there are just enough of them to open our pores and facilitate our sweating) or the disagreeable sensations of burning heat (if they start to tear our flesh apart). This is something that does conform nicely with observation. We do feel pain from hot bodies

precisely to the extent that they look to be tearing at our bodies, and it takes sharp particles to do this. Moreover, fire does obviously tear things apart. And we do find that motion produces heat.

The theory also does an excellent job of accounting for the phenomena of burning. Penetrating other bodies, the ignicoli either crumble the architecture of the body and cause it to collapse (in effect, to melt), or get caught in pores in the bodies, where they bounce and vibrate about for some time, or they tear the other bodies parts into little, fast-moving parts like themselves, generating yet more ignicoli and producing a conflagration (this is what happens when the ignicoli ignite some flammable material). An intense conflagration may even account for light and it would be a particularly attractive feature of the theory if this were so as it would bring two sets of phenomena that were previously thought to be distinct, the phenomena of heating and burning and the phenomena of luminescence, under a single explanation. Idol of the tribe though it may be, the ability to unify disparate phenomena under a single account is an attractive feature of a theory.

Galileo attempted to further justify the theory by a form of argument that we now call inference to the best explanation. He picked on a particular case that is a problem case for the Aristotelian theory and argued that his hypothesis is to be preferred because it is able to explain both everything the Aristotelian theory could explain and this problem case as well.

The case is that of the heat emitted by a piece of "calcified stone" (calcified stone is the lime that results from heating limestone in a cement kiln) that has been moistened. On the Aristotelian account, this phenomenon is unaccountable since both the water and the stone can be supposed to be cold at the outset of the experiment. That the form of heat should suddenly emerge upon contact with something that is not warm, but itself cold, is contrary to anything the Aristotelian theory could easily explain. But Galileo claimed to be easily able to explain the phenomenon mechanically. When the stone, which is somewhat porous, was roasted in the kiln, ignicoli came to be trapped in its pores, where they have since been bouncing about and vibrating. Upon immersion in the water, the pores of the stone are for some reason widened, the ignicoli are able to escape, and heat or warmth is felt.

(As a matter of fact, the heating Galileo described, which is actually quite significant, is the product of a chemical reaction. This indicates that the "best explanation" that can be offered for a phenomenon at any given time is not necessarily anything close to the correct explanation, but "inference to the best explanation" has continued to be a popular means of justifying a theory down to the present day.)

Galileo did not prove that heat could not be a quality actually inhering in bodies, any more than he proved that colour, smell, or taste could not be such qualities. He merely articulated a theory that takes heat and the other sensible qualities to be effects of purely mechanical causes and hoped that the theory's agreement with the phenomena, its ability to unify different phenomena under a single explanation, and its ability to account for previously unaccountable phenomena would induce people to accept it in preference to its rivals, or at least to consider it a working hypothesis that is worthy of further investigation.

ESSAY QUESTIONS AND RESEARCH PROJECTS

1. Galileo supposed that sensible qualities "reside exclusively in our sensitive body." Consider what this might mean and whether this is a plausible or consistent view. Would it have been possible for him to deny that sensible qualities exist even in us? If they exist in us, how do they exist in us? Did Galileo mean to endorse the Aristotelian view that for me to

sense a quality like red or hot is for me to literally become red or hot? If he is willing to allow that sensible qualities exist in our sensitive body, then why not allow that they exist in other bodies as well?

2. Assess the adequacy of Galileo's argument against the objective existence of sensible qualities. Are the considerations Galileo advanced for his position really compelling? Are they too compelling, that is, might they work just as well to prove that shape and motion have no objective existence? Might Galileo have advanced other, more compelling arguments against the objective existence of the sensible qualities (think of the traditional sceptical modes or the reasons advanced by Epicurus in the letter to Herodotus)? Would these arguments have been "too compelling" (in the sense just mentioned) had he dared to use them? Could an Aristotelian mount an equally compelling argument for the rival view that sensible qualities do inhere in objects?