

Remnants of Substances: A Neo-Aristotelian Resolution of the Puzzles

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The rehabilitation of Aristotelian hylomorphism as an account of nature is fully underway. Recent developments in science, including quantum mechanics, quantum chemistry and thermodynamics, and relativity theory have opened up new space in the philosophy of nature for Aristotelianism, or so I have argued (Koons 2017, 2018a, 2019). However, any proponent of an Aristotelian revival must frankly confront the fact that many features of Aristotle's account of nature have been refuted and superseded. There's no returning to five elements or to crystalline spheres in the heavens. In response, we Aristotelians insist on a distinction between primary and secondary features of the Aristotelian paradigm: between the essential core of the program and dispensable conjectures built upon it. I will focus in the paper on a set of potential challenges to Thomistic Aristotelianism drawn from contemporary understandings of nature, namely, challenges to two Aristotelian doctrines that seem close to the core: (i) the principle that *accidents* can exist only in substances, and (ii) the principle that material or quantitative *parts* of a substance cannot exist except as part of that very substance. I will argue that the Aristotelian program can accommodate *remnants* of substances: both accidents and proper parts of a substance that survive its demise and exist separately from it.

Substances, Accidents, and Quantitative Parts

The notion of a substance (Greek οὐσία, Latin *substantia*) is central to Aristotelianism. A substance is an entity with an essence or nature, in the strictest sense of the world. The essences of substances are metaphysically fundamental, in the sense that the essence of anything else is explained in part in terms of the essences of substances, while the essences of substances are explanatorily bedrock. The priority of substantial essence has a number of corollaries:

1. Substances are *fundamental* entities, in the sense that each substance has its own act or fact of actual existence, a fact that is not even partially grounded in the actual existence of anything else.¹
2. Substances are *unified* in the strictest and most fundamental way. A substance is one thing, and its unity does not depend on anything distinct from it and its essence.²
3. Substances *persist*, and the essences of substance do not change but are the grounds (at least partially) of all intrinsic change.
4. Substances are the fundamental bearers of *causal powers* (both active and passive) and so are the ultimate truthmakers of dynamic laws of nature.

Orthodox Aristotelians hold that the world contains more than one substance, and that it contains, in addition to substances, two further kinds of things (*res*): accidents and quantitative parts of substances. Therefore, Aristotelians accept two theses rejected by Democritean materialists (both ancient and modern): that there are composite substances, and that substances undergo intrinsic change. There are a variety of interpretations of Aristotle (especially of the *Categories*) and a variety of contemporary versions of Aristotelianism that differ in their understanding of both accidents and parts. I will assume here (for the sake of simplicity) that accidents are abstract particulars and not universals (following Thomas Aquinas, and contrary to Michael Loux 2008 or David Armstrong 1996). I will also assume that quantitative parts of substances are neither accidents nor substances (in the strict sense), although they belong in a derivative way to the category of *substance*. The axiom that no substance can have other substances as parts is fundamental to the system, in my view. Aristotle, *Metaphysics* 1041a5: “No substance is composed of substances.”

¹ More accurately, substances are composites of two fundamental entities (a substantial form and some prime matter), each of which is fundamental in a different way. The substantial form is a fundamental source of actual existence and of nature, while the prime matter contributes fundamental numerical distinctness from other substances of the same kind (Koons 2018b). Nonetheless, there is a sense in which it is substances that *exist* fundamentally, since the substantial form exists only in a secondary sense, by virtue of being the source of existence for the substance, and the prime matter derives its actual existence from the actual existence of the whole.

² This also has to be qualified, since the substance is, in a sense, a *composite* of form and prime matter. However, neither the form nor the matter is a *part* of the substance in the ordinary sense of the word. The prime matter is simply the whole substance *qua* bare particular (*qua* unformed), and the substantial form exists by providing the substance with a fully unified existence, and is not itself one of the things that has to be unified with others in constituting the whole.

To use some helpful scholastic terminology, accidents can be either *proper* or *contingent*. A proper accident is one that flows necessarily from a substance's essence. It is an accident that the substance cannot be without, like the accident of humans of *being capable of laughter* (risibility). Nonetheless, there is a clear asymmetry between the substance's essence and any of its proper accidents: the essence explains why the substance has the proper accident, and not vice versa. So, for instance, human rationality explains risibility and not vice versa. Contingent accidents are crucial to the Aristotelian account of intrinsic change. When a substance undergoes intrinsic (non-Cambridge) change, it gains or loses some contingent accident.

We can distinguish between an accidental form, the accident itself, and the accidental unity that results from the accident's being-in the substance. So, for example, we can distinguish the form of Socrates' musicality (that *by which* he is musical), his musicality itself, and the accidental unity that is *musical Socrates*. The accidental form grounds the accident, and the accident is a component of the accidental unity. In the parlance of modern analytic philosophy, it is the accident that is a *property* or character of Socrates, while the form is the ground of that character and the accidental unity is the whole Socrates as-qualified-by the accident. I have argued elsewhere that we should take seriously the existence of forms as distinct from properties, so I won't rehearse those arguments here (Koons 2018b). I also won't address whether accidental unities should be thought of as real or merely logical/notional beings. (One option is to think of them as wholes composed of substances and accidental forms—see, for example, Brower 2014.)

A *quantitative part* of a substance is a part in a very ordinary familiar way, as a finger or a particular pint of blood are parts of an individual organism. Non-quantitative parts of a substance would include the substantial form and the prime matter of the substance, and perhaps also the essence itself (composed of the substantial form and prime matter considered abstractly). I will assume that there is such a thing as prime matter, which is to be understood as a gunky form of bare particularity (Brower 2014, 134). Prime matter on my view plays the role of individuating substances of the same species (which is a controversial stance, even among Aristotelians). However, I don't think anything substantive in this paper depends on this assumption.

As I mentioned, no substance can have other substances as quantitative parts. To do so would fatally compromise the *per se* unity of the containing substance. The requirements of *per se* unity of the composite substance are so great that we have to think of the quantitative parts as metaphysically dependent on the whole, and not vice versa. The existence and persistence of the parts depends asymmetrically on the existence and persistence of the whole, and the proper accidents of the parts (including their proper causal powers) depend on the essence of the whole (Koons 2014). As a result, Aristotelians seem committed to what has been called The Homonymy Principle: no quantitative part of a substance can exist except as a part of that substance. So, a severed hand is not strictly speaking a hand at all, but only “homonymously” so, the way a picture of a dog is a “dog.” Aristotle, *Metaphysics Zeta* (1035b24-5): “For they (the parts of the body) cannot be independently of the whole (animal); since it is not any sort of a finger that is a finger of an animal, a dead finger being a finger in name only.” Consequently, no hand of a living organism can survive severance from the body, since each finger is essentially (or quasi-essentially) a finger, while the severed “finger” or the “finger” of a corpse is not. The essence of things, including quantitative parts, is tied to their telic functioning: “When seeing is removed the eye is no longer an eye, except in name.” (Aristotle, *De Anima* II.1, 412b10) Once the whole organism is dead, its quantitative parts lose their function. Thomas Aquinas agrees: “Both the whole and the parts take their species from [the substantial form], so when it leaves, neither the whole nor the part remain the same in species. For a dead person’s eye and flesh are so called only equivocally.” (SCG II.72.1484)

The Persistence of Accidents

Can accidents persist beyond the demise of their substances? There are two cases to consider: accidents of the whole substance, and accidents of quantitative parts of the substance. If quantitative parts of a substance could persist beyond the demise of the whole substance, then the accidents of those parts would also have to exist after the substance’s demise. An accident of a quantitative part is in a sense an accident of the whole substance, and so in this way accidents of a substance could persist beyond the substance’s demise, if the quantitative part could. I will take up this question in the next session.

Let's turn first to the case of accidents of the whole substance. It seems obvious that such an accident could not survive if the substance does not, since an accident is simply the substance's being-a-certain-way (quantitatively, qualitatively, or relatively). As Thomas Aquinas puts it, "Accidents have a mode of existence such that they cannot exist *per se* but only being-in (something)." (*In Metaphysica* VII, L1 par. 1254) If the substance is not actually at all, it cannot actually be a certain way. Aristotle states clearly that color must be in an individual body (*Categories* 2b2). Aquinas writes, "Accidents have no being unless they exist in a subject." (*In Metaphysica* VII, L4 par. 1352) They are incapable of independent existence (par. 1291). An accident without its substance would be something very like the smile of the Cheshire cat without the cat.

However, this inference moves too quickly. Do we know that an accident cannot have being "in a subject" when that subject no longer exists (in actuality)? And what does it mean for accidents to lack "independent" existence? Couldn't that mean that it is impossible for an accident to come into existence without receiving that existence from a substance? As Aquinas wrote (*In Metaphysica* VII, L8, 1459), substance is the "active principle" of accidents. It is impossible for accidents to be prior to substances "in definition (ratio), time, or generation." (Op cit. L13, 1579) Accidents do not have "perfect being (*esse perfectum*)" unless they exist in a subject. (L9, 1477) This non-priority of accidents seems compatible with some accidents continuing to exist after their substances have been destroyed.

In addition, John Wippel (Wippel 2000, 253-65) and Stephen Brock (Brock 2014) have argued that every accident has its own act of being (*actus essendi*), an act of accidental being or being-in, which is distinct from but dependent on the act of existence of the whole substance. This at least raises the conceptual possibility of an accident's existing in the absence of the existence of its substance.

In one case, as is well known, Aquinas explicitly affirmed the possibility of the persistence of accidents in the absence of their subjects: the accidents of the Host in the Eucharist (transubstantiation). Aquinas discusses this in the *Summa Theologica*, Part III, q77 a1. Aquinas asserts in the second Reply that we cannot simply identify the definition of *accident* with *being*

in a subject, although it is a consequence of the definition of accident that they naturally have their existence in a subject. Consequently, it is not a contradiction in terms to say, ‘This accident is not in a subject.’

Nonetheless, Aquinas affirms in the same article that in the common order of nature (*sans* miracle) an accident must be in a subject. So, if we set aside direct exercises of divine power, it is impossible for accidents to persist after their substances have ceased to exist. It seems that this conclusion is grounded in conjectures about the common course of nature that are revisable in the light of new information, without sacrificing anything indispensable to the Aristotelian framework. In other word, the synchronic dependence of accidents on their substances is a secondary rather than primary feature of Aristotelianism.

In addition, there is at least one case of an accident for which this synchronic dependence was not even a secondary postulate: the accidents in the category of *action*. The accident of action exists *in* the patient, even though it is an accident *of* both the agent (and, *qua* *passion*, the same change is also an accident *of* the patient). In *Physics* 3.3, Aristotle teaches that the action and the passion are the same movement, and that the movement of the patient is the fulfillment or actuality (*entelechia*) of both the agent and patient. This real identity of action and passion, and the identification of both with movement or change in the patient is affirmed also by Aquinas in many places, including *In Physica* III, par. 1268-9, ST I, q 29 a3 ad 1, and ST I, q 45 a2 ad 2. The action of the agent is not complete until the change in the patient has reached its natural culmination, even if the agent and patient are not in continuous contact, as Aquinas explains in *De Potentia* 3.11 ad 5:

An instrument is understood to be moved by a principal agent so long as it retains the power (*virtus*) impressed by the principal agent; whence the arrow is moved by the archer so long the force imparted by the archer remains... It is necessary that the mover and moved be together at the beginning of the motion, but not for the whole motion, as is evident in projectiles.

Suppose the archer dies before the arrow's motion is complete. In that case, the archer's accident of action persists beyond the duration of the substance's existence. A similar point is acknowledged by Aristotle in Book I of the *Nicomachean Ethics*. Happiness is a certain kind of activity of a human being. Aristotle writes in Book III of the *Nicomachean Ethics* (1112b), "Things we do through the agency of our friends counting in a sense as done by ourselves, since the origin of their action is in us." Consequently, events that affect the culmination of someone's actions after that person's death (by affecting activities shared with friends) can affect the dead person's happiness.

Could we suppose in these cases that it is not the original action that produces the later changes (after the demise of the original agent), but rather new actions of new agents—i.e., a chain of distinct agents initiated by the original agent? (Thanks to an anonymous referee for this suggestion.) Three points in response. First, in many cases there is no substitute agent to take over the agential function. The air around the arrow does not make it move as it does. And we know now that an arrow can be shot in a vacuum. Second, since action does not exist in the agent, there is no reason *a priori* to rule out its persistence. And, finally, the action of other agents (like friends) can simultaneously be actions of the original agent.

This is relevant to accommodating modern quantum theory, as I have argued (Koons 2018a, 2019). Quantum particles (photons, electrons, baryons, etc.) are not individual things—they are neither substances nor quantitative parts of substances. First of all, quantum statistics (both in the Bose-Einstein and Dirac-Fermi forms), in contrast to classical Maxwell-Boltzmann statistics, does not treat indistinguishable particles as distinct individuals. Permutating the identities or haecceities of particles does not generate multiple possibilities in quantum mechanics as it did in classical mechanics. When, for example, we have a two-photon system in quantum mechanics, this is not a system containing two distinct individuals as parts. It is instead a single, indivisible system. If we consider some property of the photon, like polarization in a single dimension, then the two-photon system has just three possible states: both polarized, both unpolarized, and one polarized and one unpolarized. The third state does not sub-divide into two possibilities, as it would in classical statistics. It makes no sense to ask, Which photon is polarized? Photons in a two-photon system are exactly like dollars in a two-dollar account. When I have two dollars in a

bank account, my account is a single individual thing with a two-dollar measure. Exactly so, in the case of photons, since neither photons nor bank-account dollars are individuals. (For more details, see the chapters in Part I of Castellani 1998.)

Second, quantum particles are fundamentally wavelike in their behavior. They do not follow definite trajectories through space as individual things would. They do not typically have any location in space. Instead, they correspond to a set of potential interactions (or measurements), with probabilities attached. These probabilities are associated with whole systems of entangled particles, not to individuals.

There is one interpretation of quantum mechanics that would blunt the force of these first two arguments, namely, the de Broglie-Bohm interpretation. On Bohmian mechanics, there are individual particles with definite trajectories. However, these particles have no intrinsic features whatsoever, except location. Every other feature, including charge, mass, spin, is merely contextual, dependent on the arrangement of other particles in the universe. Moreover, in Bohmian mechanics, the cosmos forms a single, indivisible dynamic system, so it is impossible to treat any particle as a quantitative part (in the Aristotelian sense) of any localized substance. This is not an attractive option for Aristotelians. Finally, Bohmian mechanics is vulnerable to the following argument (my third).

Third, correlations of the kind described in the Einstein-Podolsky-Rosen thought experiment (subsequently verified empirically) entail that, if quantum particles were individuals, they would have to influence each other through super-luminal causation (causation whose influence travels faster than the speed of light), in profound tension with Einstein's special relativity. This is explicit in Bohmian mechanics, in which the velocity of each particle is influenced directly by the simultaneous positions of all other particles in the universe, no matter how distant. Any ontology that treats particles as individual things will have to posit some form of superluminal causation, if the EPR correlations are to be explained at all. The only alternative is to treat entangled particles as forming a single, indivisible system, with no localized states at all. This option is called treating the entangled system as *inseparable* (Healey 1991).

If entangled particles are inseparable, then they represent a span of potential interactions between their substantial source (the agent) and the substance upon which they act (the patient). In the EPR experiment, the states of the two patients jointly determine *which* potentiality of the agent is actualized. There is, however, no action of one patient upon the other, and so no violation of the luminal limit, no matter how far apart the patients are at the time of their undergoing their passion. The agent's potential action is inseparable and essentially disjunctive in character: it is a potential to influence the patients in one way if the patients are aligned in the same direction and another way if they are not. In either case, it is a single, joint action that is performed by the agent, with neither the agent nor the other patient being influenced by a patient's condition at the time of action.

Consequently, particles are not substances nor quantitative parts of substances, since both would be real individuals. Particles are merely aspects of potential actions of the substance that emits them. Substances are not in any sense composed of particles. The picture of atoms as little solar systems inside my body is untenable in light of the quantum revolution. My body is in fact a continuum of matter with the potential to act in quantized ways, and this quantization of action is what makes the metaphor of 'particle' occasionally apt.

We see distant stars by virtue of the photons they emitted (that is, by virtue of their quantized photonic actions). Many of the stars we see no longer exist, since it took millions of years for their light to reach us. When we see an extinct star, we are directly acted upon by a substance that no longer exists. The substance no longer exists, but many of its accidents of action (or potential action) do.

What is the defining relationship between substances and their accidents, if accidents can exist after the substance's demise? The relationship is one that requires only that both relata exist in potentiality. It is not necessary for both to exist in actuality. For an accident to exist in actuality, it is necessary for its substance to be actual or to have been actual in the past. This is because an accident can receive actual existence only through its substance. A substance can exist in actuality even though there are many potential accidents of that substance that are not, have not been, and will in fact never be actual. So, in the order of actual existence there is an asymmetric

dependence of each accident on its substance. But this dependence does not rule out an accident's persisting beyond the demise of its substance.

Accidents have a dual dependence on their substances. As we have seen, every accident must receive its existence at some point in time from a substance. Secondly, each accident is individuated by its substance. Any two accidents of the same type are not fundamentally or primitive distinct from each other. Instead, they derive their mutual numerical distinctness from the numerical distinctness of their substances (Brower 2016, Koons 2018b). This means that the individual identity of each accident is essentially tied to that of a particular substance.

Consequently, no accident can be transferred from one substance to another. However, that does not rule out the possibility of an accident existing on its own, in the absence of its original substance. This is analogous to what Aquinas has to say about the individuation of human souls after death: two souls are individuated by virtue of their relation to two distinct bodies, even though those bodies no longer exist in actuality. The past existence of the bodies suffices (SCG II 81, par. 8). Souls are not accidents, but both souls and accidents are individuated by something else.

How could an accident be actual at a time if its substance is not? The category of action seems to be the only case in which this could occur, in the absence of a miracle (except for the case of accidents of quantitative parts, which I take up in the following section). This is because the accident of action exists in a second substance, the patient. So long as the patient substance exists, the agent's accident of passion can exist, even if the agent no longer does. Therefore, the Aristotelian encounters no difficulty in accounting for the physical actions of substances (in the guise of emitted particles/waves) that persist after the demise of the substance.

The Persistence of Quantitative Parts

Do material substances (like organisms) have quantitative parts—parts that correspond to different regions of the space occupied by the whole substance? This question leads to a potential dilemma. On the one hand, it is the very nature of quantity to be divisible. In addition, heterogeneous substances like organisms seem to be actually divided into disjoint parts, namely,

the body's organs and discrete tissues. On the other hand, if a substance can be partitioned into a plurality of quantitative parts, what prevents the substance from being simply the heap of those parts? What is the relationship between the whole substance and the parts (taken collectively)? A weird sort of duplication seems to occur. Both the substance and the parts taken collectively occupy the same space at the same time. Can the whole do anything over and above what is done by the parts collectively? If not, doesn't the whole become causally redundant (as argued in Merrick 2001)?

Alexander Pruss at one point suggested that material substances have no parts at all. Instead, what we are inclined to call 'parts' are really just spatial accidents of the whole substance (Pruss 2014). If my right hand is warm and my left is cold, we should really say that I have the accidents of warm-in-my-right-hand and cold-in-my-left-hand. If I kick a ball with my right foot, the action is one of my accidents, an accident of kicking-with-the-right-foot. We don't need to reify the parts of my body at all.

This proposal (which Pruss has since abandoned—Pruss 2019) faces a couple difficulties. First, there is the problem of internal locomotion, that is, of locomotion of parts within substance. Rotation of the whole substance is not a problem, since this could be identified with rotation of the system of spatial accidents. Think of each substance as having its own internal 'space' associated with its size and shape. When the substance rotates, the whole associated space rotates.

But what about internal circulation and vortices? Consider the circulation of blood in the living body. It seems that there is some part of the body (the blood) that changes its location in the substance's own internal accidents. The internal accidents of spatial location cannot move relative to each other, since their relative positions are essential to them (as spatial regions). In addition, we have to explain material inflows and outflows. Consider, for example, four bodies of water, A, B, C, and D, with B and C connecting A and D. Suppose that A is diminishing and D is growing, while B and C remain constant. There must be an outflow of water from A to either B or C or both, with an equivalent outflow from B and C to D, and we can ask how much

water is flowing through each of the intermediaries. This also requires some facts about internal locomotion.

This is a problem, but not necessarily a fatal one. The reductionist can introduce a new primitive relation of genidentity (to use Hans Reichenbach's term) between spatial accidents of a substance at different points in time. Or, even better, reductionists could posit temporally extended processes of quasi-locomotion that unite continuous trajectories of spatial accidents over time. Strictly speaking, nothing loco-moves internally within a substance, but we can use this *quasi-locomotion* as the truthmaker for informal talk about such internal motions.

My second objection is, I think, fatal. At some point we have to ask: what individuates indiscernible spatial accidents of the same substance? Consider a perfectly spherical substance that is actually divided into two perfectly similar hemispheres. This certainly seems possible. Each hemisphere will have an accidental form of exactly the same kind. We have to explain what makes the two indiscernible regions *two*. So, we will have to posit a pair of individuating factors responsible for the numerical distinctness of the two hemispheres.

Therefore, every quantitative accident of a substance should be associated with a bare particular. This should be true of potential parts of the substance's location as well as actual parts. Let's assume that the occupied parts of space include no simples (that is, no points). Then we will have a *gunky* (to use David Lewis's term) continuum of bare particulars associated with each material substance. This gunky continuum could fittingly be called *prime matter*.

Each gob of prime matter is material and underlies some quantitative accident of spatiality. Since these accidents are proper parts of the spatial accidents of the whole substance, there is a material and quantitative *entity* (a particular thing) that is a proper part of the substance. So, material substances have quantitative or material parts. This means that we have to deal with the second horn of the dilemma and answer these questions:

1. How does a material substance differ from a mere heap?

2. When a substance is partitioned into some parts (mutually disjoint and jointly exhaustive of the whole), how is the substance different from the plurality of these parts, taken collectively?
3. If it is different from such a plurality, how can the substance occupy the same space as the parts?
4. What prevents the whole substance from being causally redundant, given the causal powers and potentialities of its parts?

I have dealt with these issues in detail elsewhere (Koons 2014). I will summarize my conclusions here.

1. A material substance differs from a heap by virtue of having a substantial form. The actual existence and the proper accidents (including the causal powers) of all of the quantitative parts of a substance are grounded by the nature of the one substantial form. The parts receive their actual existence and their nature from the whole.
2. Taking the parts making up a plurality collectively would leave out the one substantial form of the whole.
3. A heterogeneous substance (like an organism) occupies space by virtue of its actual parts' collectively occupying that space, so there is no objectionable duplication of located things. The parts are enabled to occupy space by virtue of the substantial form of the whole. A homogeneous substance or homogeneous part typically has no actual parts, but only potential ones.
4. The whole substance is the ground for the fundamental causal powers of the parts, so the whole is causally relevant. In addition, in living organisms the substantial form of the whole is the ground for the persistence of certain holistic processes in which multiple parts participate, and these processes alter and coordinate the causal powers of the parts.

Answer 3 places the issue of actual and potential parts on the table. It is essential to Aristotelianism that every substance have only finitely many actual parts. Since all of space is divisible without limit, every material body has an infinite number of potential parts. Potential parts (by definition) have only potential existence. Nevertheless, merely potential things are a

crucial part of an Aristotelian ontology. They belong to our domain of quantification, so we can truly say, *some things do not actually exist*.

Living organisms have many actual parts, corresponding to the distinct organs and tissues that make up the living body. These parts participate in various holistic processes, such as respiration, immune response, whole-body growth and development, sensory perception, inference, and coordinated bodily movements. The substantial form of the whole organism is the ground for the possible existence and diachronic persistence of these holistic processes, and the processes correspond to a kind of top-down influence on the actions and passions of the parts.

There is a threefold dependence of quantitative parts on whole substances. First, each quantitative part receives (at the time of its generation) both its actual existence and its proper nature from the whole. Second, the essence or quasi-essence of each part is defined in terms of its teleological function within the whole. The first dependence ensures that no quantitative part can be initially a part of two distinct substances (since it cannot receive its whole existence at that time from two distinct causes). The second dependence suffices to ensure that the very same quantitative part cannot be successively parts of two different substances. Therefore, each quantitative part is essentially and perpetually the part of a single substance (see Pasnau 2011, 578-587; Cohen 1996, 128-9; Marmodoro 2013). Aquinas (SCG IV, 84, par. 7) states that it is the diachronic numerical identity of the soul (substantial form) that grounds the diachronic identity of the flesh and blood (quantitative parts), and in *Compendium Theologiae*, chapter 153, he states that the numerical identity of any proximate matter depends on the numerical identity of the substantial form.

Neither of these two dependencies rules out the part's surviving the demise of the substance. It cannot become part of another substance, but it can continue to exist as a remnant of its original whole.

The third dependence is this: the quantitative accidents of the quantitative parts are accidents of the whole. So, the thesis that quantitative can survive the whole's demise depends on the possibility of accidents doing so, a thesis I defended in the preceding section.

It is possible to keep cells and even whole organs alive, after the organism as a whole has died. If the organism has died, it is impossible to generate a new organ of that same organism, although it is possible to generate new cells, given that the body uses existing cells to generate new ones. Such a process of cell generation can continue after death, as has in fact happened in the case of Henrietta Lacks, whose cells have given rise to cell lines used in laboratories 70 years after her death.

Aristotle considers such a possibility in Book Zeta of the *Metaphysics* (1040b5-15, reflecting on the fact that some parts of some animals (like worms) seem to be alive (e.g., capable of self-motion) after the animal has been dissected:

“It is evident that most of the beings that are supposed to be primary are powers (potentialities, *dynameis*). Such are the organs of animals; none of them can be... separately from its organism, and if separated they continue to be, but as matter.... One might be inclined to suppose that some parts of living bodies and of their living selves (souls, psyche) possess individual being, both actually and potentially, seeing that these parts have a source of movement in them, so that they can move from their normal places, especially in those cases in which animals, even when divided, continue to live. Nevertheless, such parts are only potentially individual beings so long as they are naturally united and continuous...” (Hope 1952, 164-5)

Aristotle seems to conclude that such detached organs exist only *potentially*. What could he mean by that? I think he’s pointing to the fact that they cannot be substances in their own right. They remain essentially parts (of a certain type) of a particular living organism (matter or *hule* of a certain kind), and they could have perfect existence (to use Aquinas’s phrase) only if (*per impossibile*) the living organism of which they are a part were resurrected. Hence, their existence is not *fully* actual. If this is right, then Aristotle is clearly rejecting what Jonathan Schaffer has recently proposed as an Aristotelian postulate: the Tiling Constraint (Schaffer 2010, 38). According to Schaffer’s Tiling Constraint, no two substances can have any part in common, and the sum of all substances exhausts the whole of natural or material reality. It is the second part of

that constraint that Aristotle seems to reject: there can exist things that are merely remnants of substances, things that are neither substances themselves nor composed of things that are parts of actual substances.

What should we say about organ or tissue transplants? In some cases, we should say that the tissue or organ continues to be a remnant of the original organism, although engineered to mimic a natural function within the recipient. This would happen in the case of relative static or short-lived transplants, like that of blood, bone, or corneas. In other cases, at least potentially, we could say that the original organ has been corrupted and a new (numerically distinct) organ generated in its place by a novel process of digestion or assimilation. As the transplant organ is nourished and even repaired by the recipient's body, a substantial change can occur, in which prime matter is acquired by the recipient's body through continuous processes of locomotion and chemical change that unite the old organ's conditions to that of the new one. This is especially clear when the organ replaces old cells under conditions provided and regulated by the recipient organism.

If quantitative parts of substances can exist as remnants after the substance has corrupted, then such parts can also exist as radicals or mavericks while the whole substance still exists. A paradigm case of this would be cancer cells, which are still clearly parts of the organism's body but no longer fully regulated by the organism's substantial form. Such parts have seceded (at least in part) from the holistic processes that make up the organism's life. They retain their original functions but they no longer fulfill them (at least, not all of them). Such maverick parts play a crucial role in explaining the death of an organism, when there is no external agent. Organisms are not equipped with the active causal power of destroying themselves, since such self-destruction would require the organism to act both as agent and patient. An organism would have to be alive to be the agent of death, and it would have to be dead at the same moment in order to be the patient.

However, nothing prevents a maverick part of an organism from being the agent of the whole organism's death. Cancer cells, for example, can kill their host without directly killing themselves. They can remain as remnants post-death, which is in fact what happened in the case

of Henrietta Lacks (the cells in laboratory cultures are actually descendants of some of her cancer cells).

The role of mavericks is also crucial to solving the medieval puzzle that led many late medieval and early modern philosophers to abandon Thomistic Aristotelianism: the brown cow/brown carcass problem (Pasnau 2011, pp. 581-3). When a brown cow dies, its carcass is typically also brown (at least, in the immediate aftermath of death). According to Thomistic Aristotelianism, nothing persists as numerically the same thing through death (except perhaps featureless prime matter). How, then, can the Thomist explain the qualitative and quantitative continuities that we observe?

The correct answer has to involve an appeal to active and passive causal powers. When a butcher kills a cow (say, by decapitating it), the butcher exercises a causal power to produce a carcass that is qualitatively and quantitatively continuous with the living cow, and the living cow has a complementary passive power to be killed and to produce an appropriately quantified and qualified carcass. The only real mystery comes when a cow dies spontaneously, without any external agent. The Thomist cannot appeal to some extrinsically grounded “law of nature” in this case, since it is substantial and accidental forms of substances that are supposed to ground all dynamic laws.

However, the existence of maverick parts resolves the problem. When a cow dies without external agency, it is killed by some of its maverick parts. The active powers of those parts and the passive powers of the cow conspire to produce an appropriately quantified and qualified corpse. No numerical identity of quantitative parts or of accidents is needed.

Parts as persisting remnants thus both solve a number of modern problems generated by contemporary biological knowledge and medical technology and resolve an ancient puzzle that had led many scholastic philosophers to abandon pure Aristotelianism.

Conclusion

Both accidents and parts of substances can persist after the substance's demise, despite the fact that the accidents and parts are dependent, for their existence, nature, and identity, upon the substance. This dependency does not require that the substance exist at every moment at which the things dependent upon it exist. We can, however, infer that no part or accident could *pre-*exist its substance. These modifications in traditional Aristotelian natural philosophy require no fundamental alteration in the theory and enable it to accommodate the facts now available to us.

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