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Refinements in the Organism as a Whole Rationale for Brain Death

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Abstract

Death can be defined as the permanent cessation of the organism as a whole. Although the organism as a whole is a century-old concept, it remains better intuited than analyzed. Recent concepts in theoretical biology including hierarchies of organization, emergent functions, and mereology have informed the idea that the organism as a whole is the organism's critical emergent functions. Because the brain conducts the critical emergent functions including conscious awareness and control of respiration and circulation, the cessation of brain functions is death of the organism. A newer concept, the brain as a whole, may offer a superior criterion of death to the whole-brain criterion, because it more closely matches accepted clinical brain death tests and confirms the cessation of the organism's emergent functions. Although the concepts of organism as a whole and brain as a whole remain vague and in need of rigorous biophilosophical analysis, their future precision will be restricted by the categorical limitations intrinsic to theoretical biological models.

Keywords

Brain as a whole, Brain death, Brain stem death, Criterion of death, Definition of death, Emergent functions, Organism as a whole

Among the ongoing controversies over brain death that which remains most hotly contested is whether brain death is conceptually equivalent to human death. That this fundamental question continues to be debated more than a half-century after the concept and criteria of brain death were proposed may seem ironic in light of two facts. First, many bioethicists regard brain death as the singular bioethical controversy over which the greatest societal consensus has emerged, as evidenced by the enactment of laws permitting its practice in jurisdictions around the world. Second, the international medical community has accepted brain death as a professional standard for declaring death. Physicians continue to declare brain death in intensive care units throughout the world, either unaware of or unconcerned by the conceptual controversies over it that continue to swirl within the academy (Bernat 2014).

Over the past decade, established opponents of brain death have been joined by a cadre of younger scholars framing their arguments with increasing sophistication. As a long-standing participant in these discussions, I have observed an uptick in critical journal articles and in academic conferences highlighting the arguments of brain death critics. Many of these critiques appear to have been stimulated by recent highly publicized medicolegal cases challenging the validity of brain death (Lewis and Greer 2017).

Despite the persisting conceptual controversies and high-profile legal cases, the societal acceptance of brain death continues to grow throughout the developed and developing world, notwithstanding

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indigenous differences in laws and medical practices governing its determination (Wahlster et al. 2015). Yet the growing global acceptance of brain death masks the fact that, for decades, surveys consistently have shown that medical and nursing professionals as well as laypersons fail to understand its exact meaning, often conflating it with coma, vegetative state, and other less severe and potentially more reversible forms of brain damage (Joffe et al. 2012). Moreover, many surveyed people fail to recognize that brain death is a legal standard for determining human death (Siminoff, Burant, and Youngner 2004).

Given that brain death is the current medical and legal standard of death determination in most of the world, in addition to the obvious need for improved professional and public education about it, greater efforts need to be devoted to the conceptual task of justifying the equivalency of brain death with human death. Alan Shewmon (1985), who early in his career was a strong supporter of brain death, has shown inadequacies of the original rationale that the brain was the central integrator of the body (Shewmon 2001).[1] My long-standing defense of brain death as human death centers on the cessation of the human organism as a whole, a concept related to but distinct from bodily integration. In this article, I offer a refined account of the organism as a whole to more convincingly explain how its cessation spells death.

Historical Aspects

The original propositions for brain death as a standard for human death did not provide a rationale or conceptual argument to justify this new way to declare death. Thus, the Harvard Ad Hoc Committee's influential report in *JAMA* in 1968 that first provided criteria for the determination of what they regrettably and misleadingly called "brain death," asserted but offered no proof that such patients were dead. Instead, the report emphasized the harms befalling patients and their families if continued ventilator treatment were required in hopeless cases of permanent unconsciousness and the instrumental lifesaving benefit conferred upon others by organ transplantation after the patient was declared dead (Ad Hoc Committee 1968).

Over the next decade, as the new idea of brain death became codified into law and practiced by physicians, scholars began to address the question left unanswered by the Ad Hoc Committee: why were brain-dead patients truly dead? Scholars offered a variety of conceptual rationales for the equivalency of brain death with human death, notably by the Task Force on Death and Dying of the Institute of Society, Ethics, and the Life Sciences (1972, Capron and Kass (1972), Veatch (1976), Veith and colleagues (1977, Parts I and II), Korein (1978), Bernat, Culver, and Gert (1981), and the US President's Commission for the Study of Ethical Issues in Medicine and Biomedical and Behavioral Research (1981). The rationales offered to justify brain death varied including the brain as the control system or central integrator of the body, the brain determining that which was unique to the nature of man, and the brain as the seat of the organism as a whole. The rigorous analyses of death by Capron and Kass (1972), Bernat, Culver, and Gert (1981), and the President's Commission for the Study of Ethical Issues in Medicine and Biomedical and Behavioral Research (1981) were structured to proceed from the conceptual to the measurable. This systematic and sequential analytical approach has been followed by most subsequent scholars.

The Essential Role of Intuition

Coupling the increasing international medical and legal acceptance of brain death with data showing that most professionals and laypersons failed to clearly understand it suggests that its acceptance rests substantially on intuition. What accounts for the widespread intuitive attraction to brain death? In my decades of experience defending brain death as human death, I have observed varying levels of understanding spanning from the inchoate and purely intuitive to the more rigorous and sophisticated.

At a purely intuitive level, many laymen and professionals sense a qualitative life-state difference between the permanent cessation of all brain functions and the cessation of other organ functions. These people intuitively grasp that while many parts of the technologically supported brain-dead patient remain alive, the patient has died. The essence of this intuition is the recognition of the fundamental distinction between the life status of an organism's parts and of its whole. As dramatically shown by the examples of *ex vivo* cell cultures and tissue and organ transplantation, parts of the human organism can be kept alive for prolonged periods by technology after the organism has died.

The next level of understanding is medical. This stage features a physiological understanding that the brain controls and regulates many bodily functions and its loss signals death. People operating at this level of understanding consider the brain-dead patient to be dead and others "as good as dead" (Kilcullen 2014). The latter concept is distinct but often is conflated with the former. Surveys of physicians disclose their general acceptance of brain death but offering varying medical rationales to justify it (Joffe et al. 2012). One survey found that physicians trusted the accuracy of brain death determinations more than circulatory death determinations (Rodriguez-Arias et al. 2013).

The most sophisticated level is that resulting from conducting a rigorous biophilosophical analysis of death and understanding how criteria are chosen to satisfy definitions and how tests are chosen to fulfill criteria. Obviously, few people have pursued understanding to this level. But even those who possess this sophisticated understanding also continue to rely heavily on intuition. For example, in a National Institutes of Health (NIH) working committee meeting in March 2018 on the ethical aspects of neuroscience research supported by the NIH BRAIN Initiative, when explaining their research, two leading neuroscientists made the same intuitive claim: "we are our brains."

A particularly insightful intuitive paradigm considers the life status of victims of decapitation. In the twelfth century, Maimonides is said to have claimed that victims of judicial decapitation were immediately dead and that the twitching observed temporarily in muscles of the decapitated body did not represent evidence of life because it was not generated under central control. More recently, surgical decapitation has been used as a thought experiment to analogize brain death. At an early career stage, before he became an opponent of the validity of brain death, Shewmon (1985) constructed a detailed and persuasive decapitation thought experiment that powerfully and influentially showed why brain death was human death (pp. 43–47).

Although Shewmon now rejects his former conclusion of the thought experiment, others have continued to support it. Lizza (2012) defended the decapitation thought experiment to argue for the equivalency of brain death and human death in responding to a critique of it by Miller and Truog (2010). Shewmon's thought experiment, that Miller and Truog (2010) called the "decapitation gambit" (shortened and slightly modified), posits a controlled surgical decapitation in which the resulting head and torso-limb (body) portions each is attached to separate life-support systems that successfully maintain them alive. In a second operation, portions of the skull with the face preparation are transplanted to the body portion, allowing the brain, eyes, and ears to be perfused with oxygenated blood by a life-support system. These procedures are performed rapidly so as to allow the brain/eyes/ears portion to retain consciousness and remain capable of communication. The thought experiment poses the question: in which of the two portions does the living person reside?

The brainless partial skull/body portion physically resembles the original person but is utterly unresponsive despite its beating heart, circulating blood, and chest rising and falling with each air infusion by the ventilator. By contrast, the brain/eyes/ears portion on cardiorespiratory life support remains aware, sentient, and communicating. To advocates of the decapitation gambit thought experiment, the living person clearly resides in the brain/eyes/ears portion, while the body portion is analogized to a brain-dead patient.

In a rigorous biological analysis of personal identity, Olson (1997) showed that we are our biological organisms. Shewmon's thought experiment epitomizes the intuition that we are our brains.[2] The person-brain equivalency has been the subject of lengthy philosophical inquiry into personal identity including thought experiments imagining brain transplantations. The current prevailing opinion is that personal identity follows the location of the brain, not that of the rest of the body (Olson 2017).

Categorical Limitations of Theoretical Biology

An underappreciated constraint on all analyses of death employing biological constructs is the set of inherent categorical limitations imposed by theoretical biology. Rigorous biophilosophical analyses of the nature and moment of death depend on the existence of discrete biological categories such as "living" and "dead" to identify the threshold between them. Biologists who have attempted to define life recognize the intrinsic limitations imposed by identifying the criteria that are necessary and sufficient for membership in these categories that accurately and comprehensively depict reality.

In their classic texts, Schrödinger (1944) and Margulis and Sagan (1995) attempted to define life. This task analyzes the physicochemical nature of all life to distill its abstract concept, focusing particularly the role of the second law of thermodynamics, which is the only physical law that addresses order (Macklem 2008). Prigogine and Stengers (1984) showed how life was an antientropic phenomenon. By importing energy into chemical systems, organisms are able to reverse the inevitable entropic deterioration into disorder required by the second law.

Life is therefore an open thermodynamic system that allows it to overcome entropy by actively importing energy from the environment into the organism. More recent definitions of life add required higher-level features including its self-organization and self-regulation.[3]

Of greater relevance to our subject than an abstract definition of life is the task of determining those criteria that distinguish living from nonliving forms. Commonly cited lists of criteria (e.g., metabolism, homeostasis, reproduction) successfully include most plant and animal species, but, inevitably, borderline cases exist that do not satisfy all the criteria. Most biologists consider a spore and a virus as alive, though they require interacting with another biological system to demonstrate features of life. Then what about naked DNA or RNA strands with the capacity to autocatalyze and self-replicate? And what about prion proteins which entirely lack nucleic acids yet somehow can induce fatal degenerative communicable diseases? These entities possess some but lack many of the criteria of life forms. The inescapable conclusion is that all members of the immense diversity of life forms cannot be neatly separated into distinct categories delineated by specific criteria that correctly and comprehensively classify them into either living or nonliving categories.

Identical biological imitations exist for theoretical models of death, that is, constraints on the attempt to formulate necessary and sufficient conditions that neatly separate living from dead organisms. Therefore, perfection in any biophilosophical analysis of life or death is an unattainable goal. We need humility to recognize that our theoretical models that distinguish living from dead organisms are mere approximations of biological reality. It is conceptually greedy to demand perfection in such models because, without overstating the case, it is an unrealistic goal given the complexity of the task. We should not demand more rigor and specificity from theoretical biological formulations than their intrinsic limitations permit and keep these categorical limitations in mind as we note the imperfections of biophilosophical formulations of death.

Essential Theoretical Biological Concepts

Understanding three related concepts of theoretical biology helps to inform the analysis of the organism as a whole: organismal hierarchies, emergent functions, and biological mereology. These concepts that are essential to analyze the organization and operation of life forms were developed by twentieth-century biologists and since have been refined by successive generations of theoretical biologists.

The hierarchies of organization within an organism have been described for centuries. The levels are nested functionally, that is, their distinct parts are ordered hierarchically as cellular organelles < cells < tissues < organs < organ systems. The components at each level are alive, but each level of life displays distinct features. Each hierarchical level of the organism possesses a mechanistic property of unity not possessed by lower levels. The levels are nested such that wholes at lower levels function as parts at upper levels (Findlay and Thagard 2012). The functional relationships among the levels are bidirectional. An organism's levels of composition function in a bottom-up direction, while its levels of control function in a top-down direction. These more sophisticated mechanistic models have replaced the older and simpler "layer-cake" models of levels in most contemporary biophilosophical analyses (Eronen and Brooks 2018).

The stratified levels of organization within an organism and their functional relationships culminate in the functioning of the organism as a whole. As Condic (2016) explained, "all the activities of the organism are globally and autonomously integrated to promote the life, health, and maturation of the organism as a whole" (p. 260). The integration of the organism's parts is accomplished autonomously by its parts acting in service of its whole.

The unique higher-order property that each hierarchical level exhibits, but that is absent in lower levels, is called an emergent function because it emerges spontaneously when ensembles of lower levels normally function in place. Emergent functions are holistic: they are collective functions of a whole entity not localizable or reducible to any of its parts. They are self-organized in that they require no controlling external agent, but they do require interactions among the component parts (Macklem 2008). Emergent functions are observable within many physical, chemical, and biological systems. Much has been written by complexity and chaos theorists about the unique nature of emergent functions. In biology, emergent functions also comprise an essential mechanism of spontaneous biological self-organization (Kauffman 1993), a key life process creating order from chaos (Prigogine and Stengers 1984) and (in addition to natural selection) in driving the evolution of life (Kauffman 2008, 101–19).

Emergent functions have unusual and counterintuitive properties. They arise in complex systems but cannot be predicted accurately or even understood clearly merely by studying the component parts of the system because of its complexity. Emergent functions can be ranked on a scale of increasing intricacy. Simple emergent functions are those that can be potentially understood by studying their component parts, but doing so requires a complete knowledge of the structure and function of the parts as well as the precise mechanisms of their individual and collective interactions. For example, the fluid property of room-temperature water is an emergent function not present in individual H_2O molecules but that becomes present in macroscopic volumes containing enormous numbers of them. Trying to understand the emergent principles of hydrodynamics merely by studying individual H_2O molecules requires knowing their precise group interactions based upon their molecular structural configuration, molecular polarity, forces of mutual interaction, and the temperature and purity of their collection. Given the relative simplicity of this task (when compared to that of many other emergent functions), the hydrodynamic properties of liquid water may be termed simple emergent functions.

The phenomenon of conscious self-awareness is the quintessential example from the furthest other end of the intricacy spectrum. Conscious awareness is an exceedingly complex emergent function, or almost certainly, a constellation of interdependent and complementary complex emergent functions, arising from multiple structural-functional hierarchies in the brain. This most exquisite and ineffable phenomenon is somehow an emergent function of the natural ensemble of massively parallel-processed, distributed, and hyperconnected networks of brain neurons. Of course, the neuroanatomical and neurophysiological mechanism by which these networks produce conscious self-awareness remains entirely mysterious and no one understands how it is created.[4]

For our present purposes, we restrict our attention to biological emergent functions. Here, the subunits or parts are the naturally occurring hierarchical ensembles of cells, tissues, organs, and organ systems comprising a higher vertebrate organism. Tissues possess emergent functions not present in their component cells and organs possess emergent functions not present in their component tissues. In an analysis of death of the organism, we concern ourselves with the emergent functions of the organism itself resulting from the interaction of all its component parts and systems that encompass and result from the emergent functions arising at each level. It is the presence or absence of these highest-level emergent functions that is relevant to the organism as a whole.

The third theoretical concept worthy of brief review is mereology: the branch of philosophy and mathematics that studies the relationships between a whole and its parts and among its parts. As with emergent functions, we restrict our focus to mereology within biological systems (Winther 2011). A key biological mereological principle is the distinction between the ontological status of a whole organism and of its parts. That is, some of the organism's parts may continue living, given technical physiological support despite the absence of the whole (death of the organism), as exemplified by *ex vivo* cell cultures and tissue and organ transplantation that continue to thrive after the donor's death. Experts in biological mereology state this relationship most explicitly: an organism and the sum of its material components are mereologically distinct (Crane 2012).

A second mereological principle is the directionality of the relationship between the parts and the whole. The parts of an organism instrumentally serve the whole organism as its final end and benefactor. Although the whole also serves its parts by providing for their continued health during its life, the instrumental service of the parts to the whole is evolutionarily paramount. The parts of an organism cannot survive outside the organism or after the organism's death without external technological support, but the organism can survive the removal or death of many of its parts.

The Concept of the Organism as a Whole

The organism as a whole is a vague theoretical concept, which remains better intuited than explicitly characterized. Its idea was germinated more than a century ago and famously described by the biologist Jacques Loeb in his classic monograph in 1916. Loeb's project was to rigorously explain that all biological processes of an organism are ultimately the result of component physical and chemical processes. He eschewed any contribution by prevailing "vitalist" extra-physical explanations of life that could not be reduced to physicochemical properties. Today this approach, which philosophers might term reductionistic, is shared by the overwhelming majority of neuroscientists. Loeb (1916) described an organism's hierarchies of functions at whose apex was the organism as a whole, but he did not offer specific criteria for delineating the organism as a whole or identifying its essential features.

The organism as a whole is distinct from the whole organism. The whole organism is the sum of the organism's parts, whereas the organism as a whole embodies holistic functions that make the whole greater than the mere sum of its parts. Removal of parts of the organism, such as an amputated limb or a malignant kidney, diminishes the whole organism but has no impact on the organism as a whole. The organism as a whole refers to the unity of the organism resulting from the interrelatedness of its parts and their harmonious function to serve the whole. More specifically, it refers to the organism's emergent functions that serve its health and continued well-being.

A noteworthy attempt to add precision to the nature of the organism as a whole was made by Bonelli, Prat, and Bonelli (2009). Their analysis began with criteria for life forms: they have a delimited unity characterized by (1) dynamics (signs of life)—such as metabolism, regeneration, growth, and propagation; (2) integration—the requirement that the life process derives from the mutual interaction of its component parts; (3) coordination—the requirement that the interaction of the component parts is maintained within a certain order; and (4) immanency—the requirement that the preceding characteristics originate from and are intrinsic to the life form.

They then identified four criteria that determine when a life form becomes an organism: (1) completion—the requirement that an organism is not a component part of another living entity but is itself an intrinsically independent and completed whole; (2) indivisibility—the condition of intrinsic unity holding that no organism can be divided into more than one living organism, and, if such a division occurred and the organism survived, the completed organism must reside within one of the divided parts; (3) self-reference or auto-finality—the characteristic that the observable life processes and functions of the component parts serve the self-preservation of the whole, even at the expense of the survival of its parts, because the health and survival of the living whole is the primary end in itself; and (4) identity—the circumstance that, despite incremental changes in form and the loss or gain of certain component parts (that even could eventually result in the exchange of all its component atoms), the living being remains one and the same throughout life (Bonelli, Prat, and Bonelli 2009).

My colleague, Andrew Huang, and I (2019) recently supplemented the Bonelli et al. analysis of the organism as a whole. We observed that the organism as a whole has a common ontogeny shared by all organisms. It is an antientropic entity possessing processes that promote increasing biological complexity, which achieves an integrated wholeness through emergent properties. The characteristics of the organism as a whole vary with the complexity of the organism, say, as between a bacterial cell and a human being. Species variation in the organism as a whole carries an ontological significance. Although both a living bacterial cell and a human being eventually die, the events of death markedly differ. In our analysis of the organism as a whole, we therefore made a further distinction between concept and conception: the former describes in general terms the overall principles of a species-wide organism as a whole, whereas the latter describes in more precise terms the particular species-specific characteristics of the organism as a whole (Huang and Bernat, 2019).

In simple life forms, such as single-cell organisms, the conception of the organism as a whole includes the control, integration, and genetic functions executed largely by the nucleus. By contrast, the conception of the human organism as a whole includes emergent functions such as spontaneous respiration, circulatory and autonomic control, sentience, and sapience. Because these neurological processes are carried out by the brain, we referred to it as the neurocentric conception. In the human, the brain operates the majority of functions of the organism as a whole. Thus, the identical species-wide concept of the organism as a whole is manifest by markedly different conceptions that vary as a function of the organism's complexity (Huang and Bernat, 2019).

The Cessation of the Organism as a Whole in Death

In our contemporary technologic era, in which parts of a human organism can be kept alive artificially, a human's death is best conceptualized as the permanent cessation of the organism as a whole. The human brain is the final emergent neurobiological structure responsible for managing the interaction of our organism with its environment, and its control and integration capacities provide the unified wholeness of the organism. Given that the essential functions of the organism as a whole are carried out by the brain, the permanent loss of brain functions is the unitary criterion of death. This basic concept justifies the equivalence of brain death and human death.

Several scholars have made this claim using complementary arguments.

Bonelli, Prat, and Bonelli (2009) argued that the death of an organism is the loss of these four characteristics that render an organism no longer capable of functioning as a whole: completion, indivisibility, self-reference, auto-finality, and identity. They explained that the organism has lost immanency because its life processes no longer spring from itself but result from external intensive care support. The organism has lost auto-finality because whatever control over the component organ subsystem parts that remains now is directed at the level of the surviving parts and no longer at the whole. The organism has lost self-reference because the continued functioning of its parts no longer supports to the function of the whole. The organism has lost completeness because its separate component parts and subsystems no longer belong to each other and no longer constitute a whole (Bonelli, Prat, and Bonelli 2009).

The President's Council on Bioethics (2008) firmly endorsed the concept that human death is the cessation of the organism as a whole. In response to Shewmon's (2001) critique that the human organism conducted many instances of somatic integration outside the brain, they emphasized that the concept of the organism as a whole was distinct from that of somatic integration and not dependent upon it. While they concurred with Shewmon that the integration rationale of brain death was inadequate by itself, they noted that it was also an unnecessary condition for the organism as a whole. In its place, they offered a novel mechanism for the cessation of the organism as a whole—when the organism no longer was able to conduct its fundamental work.

The President's Council on Bioethics (2008) argued: "Determining whether the organism remains a *whole* depends on recognizing the persistence or cessation of the fundamental vital *work* of a living organism—the work of self-preservation, achieved through the organism's need-driven commerce with the surrounding world" (p. 60). They explained that in the presence of irreversible unconsciousness and loss of spontaneous breathing, the person was dead. They clarified that total brain failure serves as a criterion of death, "not because it necessarily indicates a complete loss of somatic integrated functioning but because it is a sign that this organism can no longer engage in the essential work that defines living things" (p. 64). The council concluded that brain death remains a valid determination of human death because the organism as a whole has ceased functioning and that satisfying this condition is not contingent on the loss of the organism's capacity for somatic integration.

Huang and Bernat (2019) further observed that the brain is essential for continued life because it is *sui generis* among organs. As evidence, we cited the current technical (but not theoretical) impossibility of its functional heterotransplantation or of its exquisite functions, particularly conscious awareness, being replicated by a machine. All organs except the brain are functionally transplantable. The functions of all other organs can be replicated, or at least have a technologically imagined replication, but not the essential emergent functions of the brain. If either of the science fiction scenarios of functional brain transplantation or replication of conscious awareness ever became possible in the future (which we doubt), it would require us to completely revise our social, ethical, legal, and biological formulations of human life and death.

Moschella (2016) also rebutted Shewmon's bodily integration critique of brain death by arguing that an organism is not simply integrated but must be self-integrated. She stated that a putative organism is a true organism if "it possesses the root capacity for self-integration as evidenced by (1) possession of the material basis for the capacity for self-integration (the capacity for control of respiration and circulation); or (2) possession of the material basis of the capacity for sentience" (p. 289). She concluded that the reason why the neurological criterion is the *only* valid criterion for death is that *only* after total brain death can we be certain that a human being has irreversibly lost the material basis of the capacity for self-integration as evidence by *both* (1) the material basis of the capacity to breathe, that is, the capacity to control the essential vital capacities of circulation and respiration, *and* (2) the material basis of the capacity for sentience (Moschella 2016).

In any formulation of death, the principal current limitation to relying on the concept of the cessation of the organism as whole is that the specific criteria that are necessary and sufficient for the organism as a whole remain to be determined. Clearly, it is the organism's emergent functions that define the organism as a whole but exactly which emergent functions are necessary and sufficient for life and death? Conscious awareness is obviously sufficient for human life but is unnecessary and its absence is necessary for human death but is insufficient. What about other emergent functions?

The capacity for circulation and respiration certainly should count as essential emergent functions. Although heartbeat is autonomous because it is generated by the intrinsic cardiac conduction system, respiration is a brain stem function as is control of circulatory muscle tone. Damage to the respiratory and circulatory centers in the medulla leads to apnea (inability to breathe) and massive vasodilatation leading to heart failure. The presence of circulation and respiration are necessary for life but insufficient if the brain is not also perfused and functional. The permanent absence of both respiration and circulation is sufficient for death but not necessary if there also has been intervening profound brain damage eliminating all brain functions (Bernat 2002).

Neuroendocrine control, temperature regulation, danger avoidance, and many other functions of the organism as a whole are more difficult to classify into essential versus nonessential functions. That is one reason that many scholars have focused principally on consciousness, breathing, and circulatory control as the essential functions of the organism as a whole that must be permanently absent in death. It also is the reason that the United Kingdom brain death formulation, influentially popularized as "brain stem death" by Pallis (1983), requires cessation of only brain stem functions, notably consciousness, breathing, and circulatory control.[5] Although conscious awareness is largely a cerebral hemispheric function, it is impossible without the inputs from the ascending reticular activating system in the brain stem.

A compelling intuitive and analytic case thus can be made to regard human death as the cessation of the organism as a whole, a necessary abstraction for our technological era in which an increasingly large number of parts of the human organism can be kept alive. The alternative formulation of death is the permanent cessation of systemic circulation causing all organ functions to cease permanently. While this formulation was necessary and sufficient for death in the era before respiratory and circulatory arrest could be reversed and supported, now it remains sufficient but unnecessary for death. With the increasing clinical use of combined artificial circulation–respiration replacement devices, such as extracorporeal membrane oxygenation, circulation and respiration now can be continued for longer and longer periods after brain and heart functions have ceased permanently. But is this tragic situation human life?

The role of the heart and lungs in the organism's health is to provide a continuous supply of oxygen to the cells, tissues, and organs of the body and to remove carbon dioxide and other waste products. Prior to around 1950, because cessation of respiration and circulation always spelled cessation of brain and all other bodily functions, the absence of respiration and circulation were valid markers for human death. But now that these cardiorespiratory functions can be maintained artificially and for a long duration, their cessation no longer has its prior causal relationship to the organism's death. It is the cessation of those brain functions providing the organism as a whole that spells death.

Future Directions: The Brain as a Whole

The formulation of human death as the permanent cessation of the organism as whole remains incomplete because the essential functions of the organism as a whole have not been fully clarified and stratified. Several building blocks are in place, but the organism as a whole edifice is unfinished and continues to remain more satisfying intuitively than rigorously.

One essential question is whether the current state of brain death justification is sufficient for it to remain a biologically plausible and a socially acceptable determination of human death. I conclude that the answer is yes because of the biological arguments I summarized here, by its powerful intuitive appeal and by its widespread level of societal and medical acceptance in diverse societies over the past half-century. But I agree with critics that the formulation of brain death has deficiencies that require attention.

One notable deficiency is the imperfect match between the whole-brain criterion of death and the accepted battery of bedside tests physicians use to determine brain death. Dalle Ave and I (2018) recently tabulated cases published during the past few decades of patients who, after being determined brain dead, were found on later examination to have retained certain neurological functions.[6] In many of our reviewed cases, we suspected that the earlier diagnosis of brain death was erroneous, thus those cases did not represent a true mismatch. But one group of cases stood out by its high frequency: those patients declared brain dead who retained hypothalamic-posterior pituitary gland neurosecretion of antidiuretic hormone (ADH), which should not occur in whole-brain death (Nair-Collins, Northrup, and Olcese 2016). The existence of this group alone suggests that the accepted battery of brain death tests do not always fulfill the whole-brain criterion.

We offered two strategies to reduce the incidence of the brain death criterion-test mismatch (Bernat and Dalle Ave, 2019). The brain death test battery could be tightened by requiring a validated neuroimaging test showing the complete cessation of intracranial blood flow, and/or the criterion could be loosened by changing the whole-brain criterion to the brain-as-a-whole criterion. The brain-as-a-whole criterion, unlike the whole-brain criterion, does not require the cessation of all brain functions but only those functions that are essential for the brain as a whole. The brain as a whole criterion is a vague concept. To sharpen it, defenders must address exactly which brain functions characterize the brain as a whole and why. Analogous to the requirements of the organism as a whole account, we argued that, at a minimum, these functions include consciousness and control of respiration and circulation (Bernat and Dalle Ave, 2019).

The British formulation of brain stem death provides a role for the brain as a whole concept. Pallis (1990) cited the brain as a whole as the conceptual foundation for brain stem death (p. 457). He argued that the brain stem is "the functional core of the brain," the cessation of whose functions was both necessary and sufficient for death. He further pointed out that the brain stem is the "through-station" conducting all ascending sensory input to the brain (except olfaction and vision) and all descending motor output from the brain. Its ascending reticular activating system is the seat of wakefulness—a necessary condition for conscious awareness—and its medulla is the source of breathing and the center of circulatory regulation. He cited evidence that cerebral hemispheric activity deteriorates once the brain stem is extensively damaged. In his formulation that the brain stem is the brain as a whole, the continued hypothalamic neurosecretion of ADH becomes irrelevant to death determination because it is not a function of the brain as a whole (Pallis 1990).

To explain the essential role of the brain stem in the brain as a whole, Pallis (1983) constructed the following analogy: "The irreversible cessation of heartbeat and respiration implies death of the patient as a whole. It does not necessarily imply the immediate death of every cell in the body. The irreversible cessation of brain stem function implies death of the brain as a whole. It does not necessarily imply death of every cell in the brain" (p. 8). He emphasized that most of the bedside tests that physicians perform to determine brain death assess brain stem reflexes and functions.[7] He criticized the whole-brain criterion as unfulfillable by pointing out that it is impossible for physicians to test all the functions of the brain in a comatose patient so physicians cannot reliably certify them as absent (Pallis 1990).[8] Since the 1970s, the concept of brain stem death has been accepted in the United Kingdom where it remains the medical and legal criterion of death (Academy of Medical Royal Colleges 2008).

Pursuing the strategy of adopting the brain-as-a-whole criterion of death moves away from the formulation of whole-brain death and toward the direction of brain stem death. Changing the criterion of death to the brain as a whole is attractive because it is congruent with prevailing medical practices in which physicians generally regard certain retained brain functions (particularly ADH neurosecretion) as irrelevant to brain death determination (Russell et al. 2019). I suspect that the understanding of the whole-brain criterion by many people more closely resembles the brain-as-a-whole criterion. It is also consistent with the President's Commission's distinction between brain cellular activities which may persist after brain death and brain clinical functions which must cease. The President's Commission for the Study of Ethical Issues in Medicine and Biomedical and Behavioral Research (1981) clarified that the concept of brain death was delineated in terms of the cessation of the brain's clinical functions, not of the brain's neuronal activities (pp. 33–34, 75).

Because the whole-brain criterion of death is embedded in many death statutes,[9] legislative action would become necessary to change it to the brain as a whole criterion. This or another action may be demanded in the United States as a result of the legal attention from recently publicized brain death cases in which the presence of certain retained brain functions after brain death has led several courts to question its very validity. Additional recent highly publicized legal cases feature family member disputes with physicians over the accuracy of the determination of brain death and family member resistance to its determination on religious grounds (Pope 2017).

Another reason to move toward the brain as a whole criterion is to unite the current international divide between countries legalizing the whole-brain criterion and those countries legalizing the brain stem criterion. International consensus on death determination is obviously desirable and has been attempted with some success (Shemie at al. 2014; World Health Organization 2017).[10] Yet, in practice, the trans-Atlantic brain death divide between the United States and United Kingdom nearly always is medically inconsequential. The two separate criteria only rarely lead to disagreements on death determination in any particular case because the overwhelming majority of patients satisfy both criteria (Wijdicks 2012).

If future analyses of the brain-as-a-whole criterion convincingly show that it satisfies the definition of death as the cessation of the organism as a whole, then the brain as a whole concept could become the postmature stage of the brain death movement. Future biophilosophical analyses that more rigorously characterize the organism as a whole also can better delineate the concept of the brain as a whole and may help to complete the project begun over fifty years ago by the Ad Hoc Committee.

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Notes

1. Alan Shewmon's critique of the integration rationale was a major stimulus driving the conceptual analysis on brain death performed by the US President's Council on Bioethics (2008). For a rebuttal, see Moschella (2016).
2. A common variation of this thought experiment, the "brain in a vat," popularized by Hilary Putnam, has generated much discussion among philosophers and psychologists. See Thompson and Cosmelli (2011) and Clark (2009) for arguments defending each side of the biophilosophical debate over whether the brain alone is sufficient for the person and how personal identity follows the location of the brain. Similar arguments are provided in recent discussions of head transplantation (e.g., see Pascalev, Pascalev, and Giordano 2016).
3. Macklem and Seely (2010) offered a noteworthy example of an attempt to define life: "a self-contained, self-regulating, self-organizing, self-reproducing, interconnected, open thermodynamic network of component parts which performs work, existing in a complex regime which combines stability and adaptability in the phase transition between order and chaos, as a plant, animal, fungus, or microbe" (p. 330).
4. Despite authoritative books on consciousness, including those with misleading titles such as *Consciousness Explained* (Dennett 1991), neuroscientists have no more than the most rudimentary understanding of a few elements of its mechanism. In fact, several scientifically sophisticated philosophers remain skeptical that, even with future scientific advances, humans will ever be able to understand the biological basis of their own conscious awareness (e.g., see McGinn 1997, 529–42; Nagel 2012). A current neurophilosophical controversy centers on whether conscious awareness is an emergent function of solely the brain or of the organism and its environment.
5. See my further discussion of the neuroanatomical correlates of the whole-brain, brain stem, and higher-brain formulations of brain death in Bernat (1992).
6. The most highly publicized such case is that of Jahi McMath. There is general agreement that she was correctly declared brain dead according to current standards. Months to years later, during continued ventilator therapy, observers alleged that she had recovered certain brain functions. Given the limited public information available about her condition, the present controversy centers over whether and which brain functions she truly exhibited. For a recent debate on the correct understanding of the McMath case, see Lewis (2018) and Shewmon (2018).
7. For a medical explanation of the usual pathogenesis of brain death that accounts for this finding, see Bernat (1998).
8. Christopher Pallis and I engaged in debates on brain stem death versus whole-brain death in person, publications, and correspondence for two decades beginning in 1979. My correspondence file contains detailed letters from him arguing the merits of his viewpoint. Upon rereading them and his articles, I now find myself more in agreement with many of his ideas than I was in the past.
9. For example, the Uniform Determination of Death Act, the model death statute proposed by the President's Commission in 1981, that nearly every state death statute thereafter adopted verbatim, or nearly verbatim, provides: "An individual who has sustained either (1) irreversible cessation of circulatory and respiratory functions or (2) irreversible cessation of all functions of the entire brain, including the brain stem, is dead. A determination of death must be made in accordance with accepted medical standards." (President's Commission for the Study of Ethical Issues in Medicine and Biomedical and Behavioral Research 1981, 73).
10. A current attempt to achieve international consensus among physicians on brain death determination is nearing completion. Entitled *Global Consensus for the Determination of Brain Death*, the project is being directed through the auspices of the Neurocritical Care Society and the World Federation of Societies of Intensive Care and Critical Care Medicine. It is scheduled to be submitted for publication in 2019.

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