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Octopuses and Ottonians: Biological Systems as Models for Decentralized Medieval Government[1]

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(with 4 figures)

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Abstract

What can octopuses teach us about history? And what did the Ottonians, the tenth-century Saxon dynasty that established and ruled the Holy Roman Empire, have in common with them? This essay is a thought experiment, postulating ways that history and biology might provide fresh insights into aspects of history that have proved elusive to historians operating within traditional historical investigative methodologies. The biological systems of octopuses, including neurobiological and physiological systems, have been used as models to inform design in a range of modern organizational applications such as US Homeland Security systems and the information self-structuring of semiautonomous robots. This article suggests that the biological systems of octopuses may also provide models for understanding the architecture of a premodern decentralized government, that of the Ottonians.

Keywords: Biological Systems, Embodied Systems, *Octopus*, Ottonians, Kingship.

Introduction

It was a great honor to be asked to contribute an article for a Festschrift volume celebrating the 65th birthday and influential career of Dr. Erich PUCHER. Dr. PUCHER's work in zooarchaeology demonstrates how much the biological sciences and archaeology have to contribute to our understanding of premodern history. His work in particular has

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expanded our understanding of the domestication and husbandry of bovines and equids, and in the process added greatly to our cultural knowledge of early European societies. As I am neither a scientist nor an archaeologist, it seemed appropriate to embrace within my own field the interdisciplinary potential suggested by Dr. Pucher's research. I am a historian, and my work primarily focuses on kingship and government in early medieval Germany. For this essay, I will use the neurobiological and physiological systems of the octopus as a model for better understanding the decentralized government that exemplified the tenth-century Saxon Ottonian dynasty.

I believe the application of biological systems models to certain aspects of history has the potential to lead to new ways of understanding premodern organizational systems. Biological adaptive systems focus on how organisms relate to their environments. The potential of natural security systems, and the possibilities they might offer for modern state security systems like US Homeland Security, have been addressed in both professional and popular literature (Sagarin 2010a, 2010b, 2012; Sagarin *et al.* 2010). The octopus as a species that can provide specific models for integrated and networked systems with specific security and semiautonomous potential has been a recurrent theme in recent years (Hochner 2012: p. R887; Sagarin 2012), and the particular intelligence distinctive to octopuses has, as well (Godfrey-Smith 2016; Gutnick *et al.* 2011). I propose that these systems, which are just beginning to be understood with regard to how they might be exploited as models for a diverse array of modern systems, offer opportunities for historians as well. For this essay, I am going to focus on the octopus. The Ottonians' ability to adapt to a rapidly changing environment, to manipulate uncertainty, and to create symbiotic relationships with former competitors, which are all key elements of an octopus's adaptive security apparatus, were key factors for the Ottonians, too, in determining their success. Using the model provided by the octopus to frame research questions about the Ottonians allows a new kind of assessment of their rule, and challenges the universality and applicability of certain paradigms that historians use for understanding the early and central Middle Ages. This paper will present the Ottonians as a case study for the application of biological systems models in historical inquiry.

The Ottonians

Europe in the tenth century presented a complex political scenario. After the death of Charlemagne in 814 CE, the Frankish empire he had consolidated under his rule was divided up among his sons. In the century that followed, these kingdoms struggled to maintain order, fighting against internal strife and competition for power as well as against external threats. The kingdom of the eastern Franks was largely made up of the territories of Charlemagne's Eastern Empire. This medieval Reich encompassed not only Germanic regions such as Saxony, Franconia, Swabia, and Bavaria but also significant portions of Italy and areas that are today parts of the Netherlands, France, and Switzerland. The Ottonian dynasty comprised five Saxon kings and emperors who first came to power with the election of Henry I (r. 919–936 CE) in 919, followed by his son

Otto I the Great (r. 936–973 CE), grandson Otto II (r. 973–983 CE), and great-grandson Otto III (r. 983–1002 CE), who died without an heir. The last Ottonian emperor, Henry II, was descended from a brother of Otto the Great. He ruled from 1002 to 1024 CE.

The Ottonians came to power at a difficult time. Like his predecessor Conrad I, when Henry I was elected king by the Saxon nobility (WIDUKIND 1935: i.25–26, pp. 37–39), he had to contend early in his reign not only with subduing some of the Germanic dukes, but also with invasions from the Magyars along the eastern frontiers, whose violent raids and demands for tribute strained any attempts at cohesive rule (WIDUKIND 1935: i.27, pp. 39–40; THIETMAR 1935: i.15, pp. 21–22; LIUDPRAND 1998: ii.21–25, pp. 44–46). From this chaotic beginning, Henry I was able to forge a semblance of order. But his rule, and the reigns of his successors, relied on methods and styles of governance that seem, to modern sensibilities, primitive. The traditional historical interpretations suggest that the Ottonians were highly decentralized, with a complex itinerary that kept the royal court mobilized because of a strong sense of the need for the actual presence of the king to ensure stability throughout their realm. The puzzle for historians thus lay in explaining how such a governing model provided infrastructure that could withstand significant internal and external pressures, including the stresses of dealing with rebellion or dynastic change. Scholars have struggled to understand how the Ottonians, with their decentralized system that gave no indication of any sense of a hierarchical bureaucracy, lack of legislative activity, and no apparent kingdom-wide efforts to create a judiciary system, were able to create effective political order and dynastic stability. The dominant position for much of the scholarship until the late twentieth century was preoccupied with trying to account for the successes of Ottonian rulership in the absence of the kinds of architectures of rulership that exemplified other medieval polities. This resulted in the development of theories such as "Königsherrschaft ohne Staat," arguing that there were essentially no administrative apparatuses of government (KELLER 1991: pp. 162–163; ALTHOFF 2005). These ways of modeling Ottonian kingship have begun to be challenged in the literature. For example, Andreas KRÄNZLE (1997) has suggested that one important element of itinerant kingship was to facilitate the absence of the king, as significant a part of itinerant rule as providing for his periodic presence. David BACHRACH has argued for a continuity between the governing institutions of the Ottonians with their Carolingian predecessors (2016: pp. 66–67). The institutions of Ottonian government continue to be debated by scholars, and our understanding of their structure and use by Ottonian kings is still evolving. This essay is intended to engage with these ongoing conversations about the nature of this polity. In the absence of a better vocabulary to employ, this article will continue to use the terms "centralized" and "decentralized," with the understanding that "decentralized" simply indicates a more complex distribution of authority than is found in traditional geographically centralized kingships with hierarchical bureaucracies.

Several key features provided for successful governance as well as dynastic resilience. One of these was the network of royal monasteries, abbeys, and churches. A second was the delegation of authority among their magnates through the granting of offices and appointments. Additionally, there was the fragmented nature of estate holding by the

king and the German nobility, and the itinerancy of the royal court. All of these factors were conducive to Ottonian success in the difficult political environment in which they ruled (Wangerin 2014: pp. 65–69; Wangerin 2017: p. 5).

According to Widukind of Corvey, when Henry I the Fowler was elected king by an assembly of the Saxon nobility in 919, it was largely because of his abilities to act as a warrior-king. He was able not only to navigate the complex relationships among the rest of the nobility and mitigate them through negotiation or force but also to muster sufficient military support from his own men and his magnates to fend off incursions from the Magyars. In 926, after successfully (if temporarily) alleviating the Magyar threat and negotiating a nine-year truce, Henry – according to Widukind of Corvey, a tenth-century chronicler – issued his *Burgenbauordnung*. According to Widukind, after subduing the Hungarians, Henry reorganized the system of burgs throughout Saxony, creating a system of fortified cities (Widukind 1935: i:35, pp. 47–49). His description is of an organized fortress system and the preparation of them for sieges. While Widukind is the only source extant that explicitly refers to this edict, Thietmar of Merseburg, another contemporary chronicler, reports that Henry restored and improved the old Roman walls around the city of Merseburg, near the eastern frontier (Thietmar 1935: i.18, pp. 80–81), and the archaeological record supports a period of active fortification during the course of Henry's reign (*e. g.*, Fehring 1991: pp. 136–138; Bachrach 2013). Unfortunately, we cannot know whether Henry's efforts were organized in the exact manner that Widukind describes, or even whether these orders were given as laws (*leges*), as Widukind asserts. Nonetheless, Henry's efforts to improve existing fortifications clearly made an impression on him. These efforts at active fortification were continued by Henry's successors (Thietmar 1935: vi.59, p. 347; Bachrach 2009: p. 392).

In addition to defense against external threats, the ability to defend against internal threats was equally important to stability in the Ottonian Reich. Each Ottonian king came to power with the support of the nobility, but this does not imply that succession was easy or uncontested. Right of inheritance to the throne was not yet established as a custom, and the Saxon nobility continually had factions that aspired to power, challenged the king's authority, and attempted to seize control during periods of transition (*Vita Mahthildis Reginae* 1841: p. 289; Widukind 1935: i.27, pp. 39–40; Kern 1956: p. 18; Liudprand 1998: *Ant.* ii:21–23, pp. 43–46). Even though rebellions were not uncommon throughout the Ottonian period, its rulers invariably had the military might and expertise to quash any coups or serious threats to their authority. This was a necessary feature of stable government and dynastic succession throughout the early Middle Ages and, while important to note, was neither unusual nor unique to the Ottonians.

What *was* unusual was another key feature of Ottonian government. Ottonian kings delegated or franchised significant regional authority to the aristocracy, and control over their realm was intimately tied to control over their magnates. The duchies served three essential purposes under the Ottonians: they were a way to recruit for armies, they acted as peacekeepers (Arnold 1997: p. 52), and the ruling groups in the duchies provided

interconnected *amicitia* networks, which relied on reciprocal obligations based on loyalty and friendship and which extended throughout the secular and ecclesiastical aristocracy of the East Frankish kingdom. This network served a number of roles, including the fulfillment of obligations or duties to the realm and the provision of opportunities for the kings to leverage personal connections and relationships. But the duties that adhered to the landowning magnates were essential components of governance of the Reich (ARNOLD 1997: p. 52). Titles such as *duke*, *margrave*, or *count* carried with them juridical, military, and fiscal responsibilities to the crown. The creation of dukes was an important part of the military organization of the new dynasty against the threats along its eastern frontiers (ARNOLD 1997: p. 46). The military successes of Henry I and Otto I against the Magyars constituted a central element of the Ottonian rise to power and ability to spread their authority across Germany even before Otto I's decisive victory at Lechfeld, and set the stage for later expansion into Italy (ARNOLD 2004: p. 27). In addition to the need to be warrior-kings that made imperative the acquisition of martial resources, of equal if not greater importance was the role of the king in maintaining the public peace, and this was done at the local level through counts and bishops. But while these delegative elements of Ottonian government are well attested, they do not suggest anything that supports what might be considered a technology of government with the mechanisms and ability to enforce the royal will throughout the realm. Those things traditionally assumed that a strong government ought to be able to do that might form such an apparatus of government, and which we do see in medieval polities such as those of the Carolingians or Anglo-Saxons, such as issuing and enforcing written laws (see, *e. g.*, ALTHOFF & KELLER 1985; NITSCHKE 2001), we just don't see deployed by the Ottonians as a regular feature of their rule (see Figs 1–2). This lack of any highly centralized hierarchical government, and the perceived absence of any indication that the Ottonians ever aspired to create such a government, has led some scholars to assert that there was no state structure or apparatus (KELLER 1989, 1991: pp. 162–163; ALTHOFF 2005). This position is increasingly being challenged by new scholarship (*e. g.* BACHRACH 2009, 2013).

Another factor that was significant to Ottonian governance was the extensive holding of noncontiguous territories. The Ottonian kings held parcels of land throughout their territories, with "interests to defend in every province," and used their interests in these regions to reinforce their relationships with local nobility, through the *amicita* networks mentioned above, or through relationships of *Königsnähe* (discussed below) (ARNOLD 1997: p. 55). This distributed landholding pattern contrasts sharply with that of France – the king of France held very little land personally throughout his realm. Instead, he held a small contiguous territory, as did most of the West Frankish nobility. In Ottonian Germany, the king's holdings were vast and spread throughout the entire kingdom. The holdings of their magnates followed similar patterns of dispersal over noncontiguous territories. This was a feature of Anglo-Saxon landholding, as well, and in both realms partible inheritance was still a general practice in the tenth century (LEYSER 1982: p. 41; CLARKE 1994: pp. 145–147). Inheritance patterns where the entire or near-entire

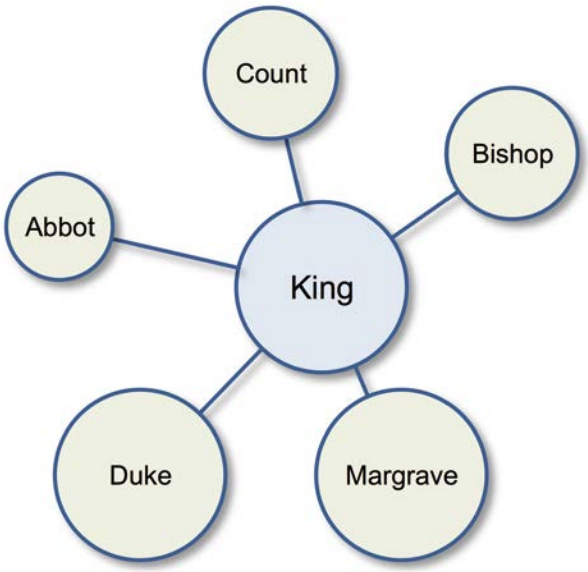

Fig. 1. A schema to visually demonstrate the octopus-like nature of Ottonian authority and jurisdictional delegation. In Ottonian Germany, secular and ecclesiastical lords ruled and held jurisdictional authority over territories of varying sizes and with varying degrees of proximity – with regard to physical distance and personal familiarity – to the king. These lords ruled semi-autonomously, and the king might at times issue orders that affected the realm as a whole, or insert himself into a local dispute. The relationships shown here are for demonstrative purposes only, and are not meant to suggest relative differences between the different kinds of authorities.

holdings of a family were inherited by a single son were not yet the norm in Germany or England, but was the predominant pattern in France. This allowed the dukes in France to amass large contiguous duchies that could act like mini-kingdoms, without the presence of other powerful men in the same region who could act as a check on power. The kinds of distributed landholding patterns that we see in England and Germany likely contributed to their resistance to the "political disarray" exhibited in France, where kings held a relatively small portion of the kingdom, and their counts' lands tended to be *"compact regions in which a single lord was dominant, and where even the greatest of lords, and to an extent, the king himself, held little or no power outside a geographically limited area"* (Clarke 1994: pp. 147–148).

The essential structure of Ottonian government consisted of an extension of the king's rule over those nobles tied to his household, then to others less close to him in regard to kinship, friendship, or proximity. These magnates were still bound to him by ties of loyalty, but obligations were imposed upon them less frequently (Leyser 1981: p. 733). In this tenth-century world, it was the proximity to great men that occasioned the opportunity to improve one's state, status, and wealth through the *amicitia* networks. Familiarity with the king, *Königsnähe*, could bring a person offices, titles, and lands. This proximity might also result in a person being entrusted with imperial business or other tasks of government, such as military duties including leading armies. Additionally, the Ottonian court journeyed continuously throughout their realm. Bernhardt (1993: 75–84) has demonstrated the importance of the *iter* to the crown, and the Ottonian rulers actively established and patronized royal monasteries where the king and his entourage were owed hospitality. But, beyond just establishing places to stay throughout the realm as the king and his court toured the kingdom, the royal *iter* was effective as a method of

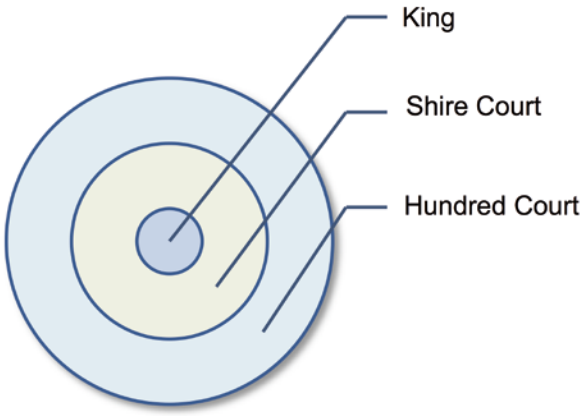

Fig. 2. In contrast to the Ottonian model, in tenth-century Anglo-Saxon England we see a system of hierarchical jurisdictional authorities. Shires, or counties, were divided into hundreds. These divisions were mainly administrative, with orders filtering down from the king through representatives at each level, and legal cases that could not be resolved at a local level moving up through the levels of courts as necessary.

rule (EHLERS 2002; ZOTZ 1991). Inevitably, some areas of the realm experienced more often than others the direct engagement of the king and his court, as there would be more frequent or lengthy stays at favorite locations, especially in Saxony. That irregularity in intensity of government throughout the Ottonian Reich is one of its significant features. Regnal authority weighed more heavily in Saxony than in the regions where the Ottonian's influence was less entrenched, areas such as Bavaria, Carinthia, Swabia, and Lotharingia (LEYSER 1981: p. 733). So while the Ottonians did have certain favorite royal centers, we do not see their government radiating out from a single geographic point – there was no capital city. The perambulations of the Ottonian court were not just an administrative necessity but also were effectively acts of assertion by the king, a means of communication, legitimation, and a reminder of his royal prerogative (LEYSER 1981: pp. 746–747; BERNHARDT 1993: pp. 56–57; WARNER 2001: p. 257; ROACH 2013: p. 46). In Germany, bishops also toured their dioceses in a manner very like the royal itinerary, *"stopping along the way to hold assemblies or preside over judicial proceedings"* (WARNER 2001: p. 265). Thus we see the same general method of governing practiced in smaller geographic areas by great and small lords, which served to ensure government at both regnal and local levels was a presence throughout the kingdom.

This is a highly simplified description of a complex political system. But the lack of a geographic center for Ottonian government, in combination with the absence of recognizable legislative activity and their tendency to delegate and franchise power to their secular and ecclesiastical magnates, has led to the customary characterization of the Ottonians: that they were somehow successful *despite* their lack of centralization. The failure of these kings to develop proto-modern political architecture or to consolidate their authority into a centralized government, as well as what has often been perceived as the deliberate dilution of royal power, all have contributed to this perception of Ottonian government (WANGERIN 2017: p. 3).

The assumption that centralization is a desirable organizational structure, and that a lack of centralization is indicative of more primitive kinds of governance, is one that

permeates scholarship on the early medieval period. This, I suggest, is a projection onto the past of modern sensibilities about government and how it works best. In medieval historical scholarship, centralization and order are ideas that are tightly entwined – decentralization must then mean disorder, which from a governing perspective suggests chaos. But many of the traditional ways historians think about and evaluate kingship are derived from early modern terminology and ideas about rulership, ideas that themselves were very much a part of the beliefs developing in the seventeenth and eighteenth centuries about what good government ought to look like. This includes dichotomies such as "centralized/decentralized," which I continue to use for lack of better descriptive vocabulary. But I propose that a new model is needed to truly understand how and why the Ottonian government was successful, and I propose that its success occurred precisely *because* of its decentralized nature.

Historians often seem to characterize the success of the Ottonians as a fluke, as something that happened despite their itinerancy and decentralized structure. They cite the failure to develop a proto-modern governing apparatus as evidence of primitivism – claiming instead that the Ottonians gave away power to their magnates without demonstrating any aspirations of creating a more coherent centralized organization, and yet somehow still becoming successful (to judge them successful by meters such as political stability, military success, cultural output, and dynastic stability) – which does not fit with models of what most historians think effective governance ought to look like (Wangerin 2017: p. 3). But if we reexamine the reign of the Ottonians using a new model, which rejects centralized control *"in favor of multiple semi-independent agents that individually solve problems as they arise"* (Sagarin 2012: p. 18), the decentralized state of the Ottonians appears to be an ideal system for dealing with the challenges of their particular situation. The ability to adapt to rapidly changing environments, to manipulate uncertainty, and to create symbiotic relationships with former competitors are characteristics ascribed to the octopus as central to its survival (Sagarin 2012: p. 29), and they determined the success of the Ottonians as well. This line of thinking about the Ottonians was inspired by Rafael Sagarin's studies regarding the application of biological systemic strategies to modern security threats. Natural systems "decentralize, adapt and cooperate" as part of the species survival strategy, a paradigm that has been suggested as a model for dealing in modern risk management for the US Department of Homeland Security and other government organizations with similar risk-assessment needs (Sagarin 2010b; Sagarin *et al.*, 2010). These kinds of natural adaptive systems *"don't plan, they don't predict, and they don't perfect"* (Sagarin 2012: p. xxv). I believe aspects of the octopus model may provide insights into the success of the decentralized Ottonian system of government.

In recent literature in the sciences, there has been increasing interest in how biological adaptive systems, which focus on how organisms relate to their environments, can address sociological problems. Raphael Sagarin has studied the adaptive systems of octopuses and extrapolated from these models to ask how a biological systems approach to security threats could be applied to modern situations (Sagarin 2012). It does not seem a stretch to revise the question slightly to ask what octopuses can teach us about history, and what

the Ottonians had in common with them. The application of biological systems models to tenth-century Germany provides the opportunity to see the Ottonians from a fresh perspective. The adaptive systems of octopuses and how they respond to threats and solve security problems evolved as species-specific survival strategies. Octopuses respond to rapidly changing circumstances using *"multiple semi-independent agents that can solve problems as they arise"* (SAGARIN 2012: p. 18). Natural systems such as this "decentralize, adapt, and cooperate" (SAGARIN *et al.* 2010). The Ottonians' ability to adapt to a rapidly changing security environment, to manipulate uncertainty, and to create symbiotic relationships with former competitors, all key elements of an octopus's adaptive toolbox for survival, were key factors for the Ottonians, too, in determining their success.

The Octopus

The neurobiological system of the octopus has many attributes that make it an attractive candidate as a model for decentralized organization and security systems. I should reiterate here that I am a historian, not a biologist, and the features I highlight below are those with particular relevance to the Ottonian system. This summary is not intended to be a comprehensive treatment of octopus biology. Most studies of octopus systems have been based on *Octopus vulgaris*, which is a common shallow-water species (HUFFARD 2013: p. 11). While generalizations extrapolated from data of *O. vulgaris* are not representative of the whole of octopus variation in nature, the possibility of a data set skewed toward the particularities of *O. vulgaris* is irrelevant for its use as a model in this essay. The morphology of octopus arms is fairly uniform across species (KIER & STELLA 2007: p. 832) and similar function has been demonstrated across species as well. The key features unique to octopuses that are relevant in this essay are the redundant appendages – the eight arms of an octopus – and its unusual nervous system.

An octopus has a wide range of body movements and methods of locomotion (HUFFARD 2006). The many arms of octopuses are flexible, sucker-lined tentacles that have significant freedom. Cephalopod appendages *"are composed almost entirely of muscle. These muscular organs, although lacking an obvious system of skeletal support, are capable of diverse, complex and highly controlled movements" via "muscular-hydrostats"* (KIER & SMITH 1985: p. 308). The arms are highly adaptable to a wide range of tasks, a *"diversity of movement and support* [that] *is not possible in more conventional skeletal support systems"* (KIER & STELLA 2007: p. 842). The arms are the primary means by which the octopus interacts with its environment, and also provide the means for the octopus to move around in its environment, employing a variety of different combinations of arms to move in a variety of ways (*e. g.*, jetting, swimming, crawling, or walking) (HUFFARD 2006: p. 3700).

The octopus nervous system is large and complex, and made up of intermingled and distributed neural networks. The majority of the nerve cells of *O. vulgaris* form ganglia and cord nerves in the peripheral nervous system (PNS), which controls single-armed movements and other lower-level activity, with only about a third of an octopus' nerve cells

comprising the small central brain and large optic lobes of its central nervous system (CNS), the system that appears to control high-level motor control (coordinated movements involving multiple arms, for example) (Young 1971: p. 13; Huffard 2013: p. 12; Budelmann 1995; Hochner *et al.* 2006; Zullo *et al.* 2009; Sumbre *et al.* 2001). The nervous system in the arms appears to function autonomously; stimulation of severed octopus arms has shown that movement can be controlled by the nerve cords and ganglia in the arms themselves, independently of the CNS (Altman 1971; Sumbre *et al.* 2001; Sumbre *et al.* 2005, 2006; Hochner *et al.* 2006: p. 310). Thus, the complex variety of body movements and means of locomotion (Huffard 2006) seems to be facilitated by a system of muscle control that allows for complex movement and coordination governed by the CNS, while allowing individual arm movement with limited amount of input from the CNS (Gutfreund *et al.* 1998; Huffard 2013: p. 14).

While the muscular-hydrostatic arms allow for a significantly more diverse repertoire of movement than a vertebrate skeletal system, the octopus brain also lacks morphological somatotopy in its CNS (Zullo *et al.* 2009: p. 1635). Vertebrates, invertebrates, and arthropods all have clear somatotopic arrangements of motor neurons. Zullo *et al.* (2009: p. 1635) have suggested that this unique feature evolved in concert with the distinctive arm structure of the octopus, where *"the relatively small central brain (~50 million neurons out of a total of ~500 million neurons) controls the large, complex, and highly autonomous PNS of the arms (~300 million neurons), as well as integrating processed information from the huge visual system (~120 million neurons)."* It was the octopus's *"development of sophisticated motor, sensory, and cognitive capabilities,"* its arms and unique neurological system, that allowed for its successful competition with vertebrates in its environment (Hochner *et al.* 2006: p. 308).

Ottonians and Octopuses

As already noted above, historians have always struggled with how to account for the success of Ottonian rule *despite* what they perceived as a decentralized state. Reuter (2006a), for example, has asserted that Ottonian Germany was *not* a highly organized polity because of the loose nature of its law and order, as well as the importance of ritualized and symbolic action, especially those with political implications, and the absence of clear administrative structures. This position is problematic on a number of levels. It appears that Reuter is falling into the trap of privileging centralization and teleology instead of approaching the Ottonians on their own terms (for these views, see Reuter 2006a: n.29; Althoff 1992; Reuter 2006b; Leyser 1984). What if, like the decentralized approach to risk developed by the octopus, a decentralized state was the *best* way to address threats that faced the Ottonian Reich? According to Sagarin's model, that decentralization could be precisely the reason they were successful. Can the *"**rejection** of centralized control in favor of multiple semi-independent agents that individually solve problems as they arise in the environment"* be reasonably compared with Ottonian government (Sagarin 2012: p. 18, emphasis added)?

There are a number of reasons that a biological systems model is a useful one to deploy here. First, and most simply, it presents an analogy about adaptive change that provokes interesting parallels with the Ottonians. Second, a biological systems model, as opposed to business or government structural models, is about more than corporate organization. A biological systems model goes beyond hierarchies of command and decision trees, providing a framework that accounts for changes within a system as it responds to external factors. Lastly, it can potentially account for an approach to governance that is more organic than an imposed hierarchical system. This is not to suggest that an organic approach to governing is more "natural" than a centralized hierarchical government – any system of governance is an artificial construct. This is an important distinction between biological systems and governmental systems: the former evolve, whereas the act of governing involves agency. At no point in this argument am I suggesting that the Ottonians lacked agency; I mean only that the system they employed bears remarkable similarities to biological security systems, and that we may gain insight into why they were successful by doing a comparison. What is being suggested here is that by using this organic structure as a model, we can potentially see how the Ottonian system provided a flexible matrix of systemic control over their territories. Using the model provided by the octopus to frame research questions about the Ottonians allows a new kind of assessment of their rule.

SAGARIN identifies *"a consistent pattern in nature – the rejection of centralized control in favor of multiple semi-independent agents that individually solve problems as they arise in the environment"* (SAGARIN 2012: p. 18). He notes that *"for the most part, centrally controlled organizations do not thrive in nature. Rather, the job of sensing the environment is farmed out to multiple agents that have a great deal of power to respond on behalf of the larger organism"* (SAGARIN 2012: p. 64). This sounds very much like the Ottonian method of delegating authority and jurisdiction. By granting their margraves, counts, and bishops broad authority in handling local affairs, they were also able to respond independently and thus quickly to threats that appeared – internal or external. SAGARIN further remarks on the three key reasons that decentralized and distributed organizations are so adaptable and thus successful: *"First, multiple sensors all looking or experiencing the environment from their own perspective provide more opportunities to identify unusual changes and unexploited opportunities.* […]. *Second, multiple agents committed to the security mission in their own local area create opportunities to specialize tasks, so energy isn't wasted in having every part of the organism doing the same thing* […] *those doing the most important things get the resources to replicate their activities.* […] *Third, distributed sensors respond to the most immediate environmental conditions in time and space – they see the environment for what it 'is' rather than what it 'should' be according to some preconceived notion"* (SAGARIN 2012: p. 67). Again, this sounds very like the Ottonian system. Having numerous local rulers able to govern with a fair degree of autonomy assured by the broad immunities granted by the king, with the king intervening or sending reinforcements only as needed to respond to specific situations, and the ability of those semiautonomous authorities to respond to situations

on the ground and react effectively, were all key elements of Ottonian success. These local lords can be seen as "multiple sensors," especially apt as a metaphor here since the vast majority of comital, episcopal, and even lesser noble estates in tenth-century Germany were noncontiguous, as discussed above. Even though every lord controlled his own realm, that realm might be broadly distributed within a patchwork of jurisdictions controlled by other lords, each with his or her own evaluation of potential threats or opportunities. Especially given the vast size of the Ottonian Empire, in situations where threats necessitated royal intervention or support, this dispersal of "sensors" allowed resources to be allocated according to need, rather than wasting energy and resources on futile attempts to predict and respond to the unrealized and unpredictable possibility of future threats (see Taleb 2007 regarding how efforts to predict future events can lead to the squandering of resources and lessen its ability to defend itself). Some might argue that Henry I's *Burgenbauordnung* was an attempt to predict and respond to future attacks by the Magyars; I disagree. The defenses built on the eastern frontier served more as a deployment of additional sensors and a means of attempting to maintain the upper hand in the violent give-and-take that defined the relationship between the Magyars and the Reich. Leyser (1981: pp. 734, 736) describes the fortress system as a *"network of burgwards and burgbanns which bound both Saxon and Slav populations to castlework, dues and watch services,"* a *"systemic and contiguous network of fortifications, of labor services, and an organization to maintain them,"* descriptions sounding much more like a sustainable sensory system with the ability to react defensively if threatened.

This network becomes even more evident as a communications system if we visualize it as an information feedback system. The octopus has been used as a model for embodied intelligence principles in order to solve complex problems in robotics. "Embodied intelligence" is a robotics idea inspired by biological systems, but one that has been reclaimed by biologists in the study of *Octopus vulgaris*'s neurophysiology and behavior (Hochner 2012). For robotics, an embodied approach offers distinct advantages in developing autonomous robots by *distributing "control and processing to all aspects of the agent (its central nervous system, the material properties of its musculoskeletal system, the sensor morphology, and the interaction with the environment)"* (Pfeiffer *et al*. 2007: p. 1088). In embodied systems, organizational behavior is determined by communication back and forth between different parts of the system, as opposed to a more traditional open-loop robotics system of hierarchical top-down control: *"In an embodied organization, the behavior arises from the system as a whole through dynamic physical and information interactions among all its components. These reciprocal, dynamical interconnections ensure that the system functions optimally in its ecological niche when each component is adapted (by evolution or self-organization) to the embodiment functionality"* (Hochner 2012: p. R887). In robotics, this means creating a feedback loop whereby a robot can spontaneously adapt to changing conditions based on its physical and informational interactions with its environment (see Fig. 3). (Pfeiffer *et al*. 2007: p. 1088).

If we compare Figure 3 with Figure 4, the possibilities of using such a model to understand decentralized Ottonian kingship become evident. The diagrams show how these

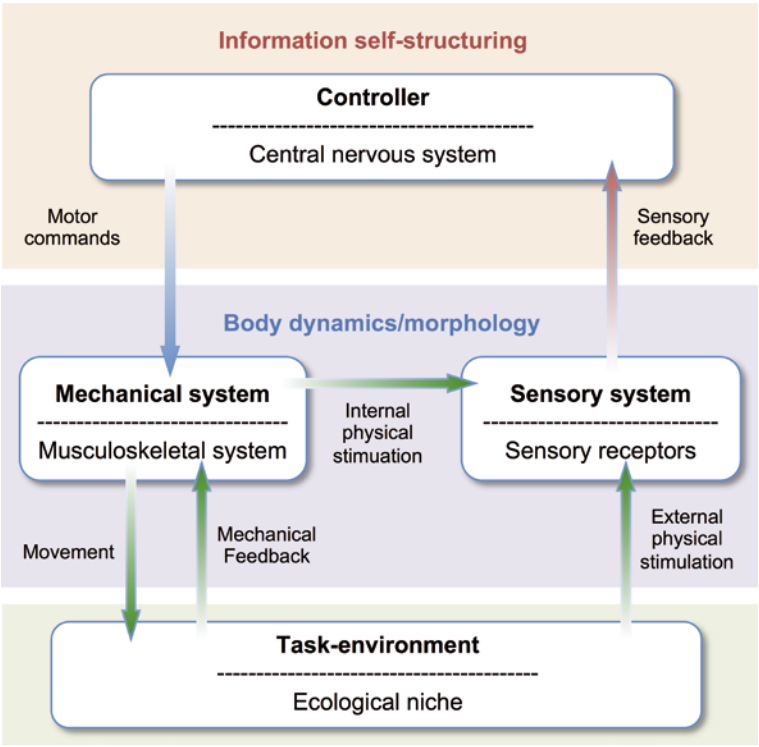

Fig. 3. A way of visualizing the behavior of an embodied system. Motor commands drive the mechanical system of a robot (or the musculoskeletal system of an organism) to act within its environment. As it receives mechanical feedback and experiences internal physical stimuli resulting from that engagement, and processes information from the environment itself, the robot has the ability to dynamically change its behavior without the need for high-level commands to control each action. Reproduced from PFEIFER *et al.* 2007: p. 1089. Reprinted with permission from AAAS.

dynamic feedback loops function as information systems. Replacing the robotics terms with terms that describe the Ottonian Reich, and acknowledging the overlapping nature of the "mechanical" and "sensory" nature of landscape of the medieval German Reich by inserting an additional arrow, we can clearly see the distibuted Ottonian governing apparatus as a communication system. The ecological niche of the Ottonian kings and emperors is their realm, a geographical space that changes over time. The musculoskeletal system is represented by the infrastructure of the Reich, the network of royal monasteries, the system of burgs, and the noncontiguous estates and holdings of the king and his magnates. The sensory receptors are the people who inhabit those spaces, who have the ability to assess the environment and both act or react to changing conditions as well as alert the king to those changing conditions. These two elements, the infrastructure and the sensory receptors, interact with each other as local authorities respond to threats or opportunities in their environment and issue low-order commands. The king himself, much like the octopus in its ecological niche, is not confined to operating from a single

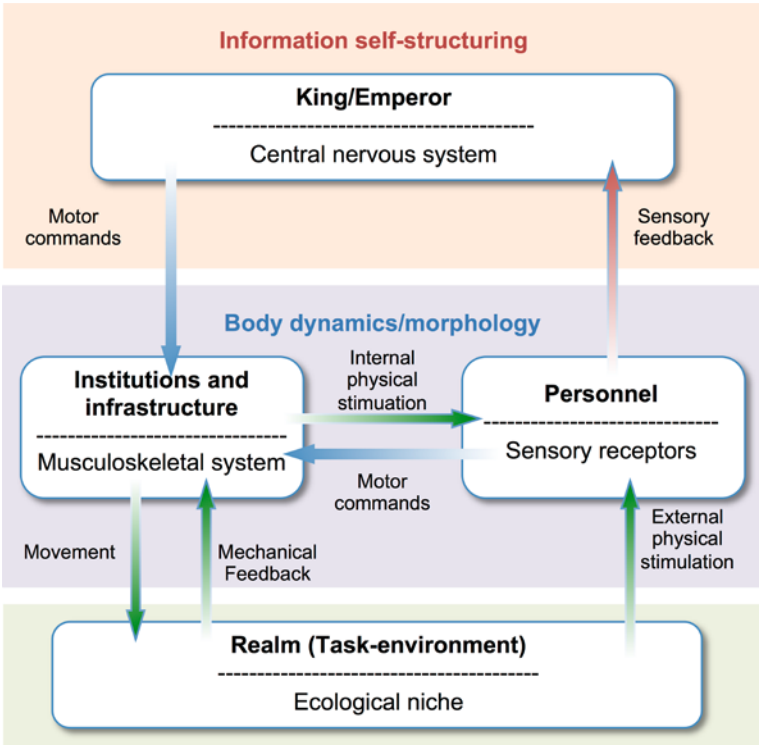

Fig. 4. Decentralized kingship portrayed by an adaptation of the embodied system modeled in Fig. 3. The institutions and infrastructure of the realm might include, for example, duchies, bishoprics, and abbeys. The people that inhabit those spaces are the sensory receptors. They receive and interpret information from the institutions they control and from their distributed sensors (estates) throughout the realm, and have the authority to issue commands and mobilize activity based on the information they receive. The king himself receives information from his magnates about the state of the realm, and may choose to issue high-level commands, but the system does not require his direct engagement to function and respond to potential threats or other situations as they arise.

location but moves about his environment, issuing high-order commands, acting according to information he receives from his internal sensors or reacting to internal (such as rebellion) or external (such as invasions) stimuli. Historians have tended to focus on formalized modes of communication, written documents, to understand how medieval kingship worked. This makes sense, as many of these kinds of formal communications have survived and generally are accessible. But the channels of informal communication and information feedback as described here were potentially equally – and perhaps even more – effective ways for Ottonian kings to rule.

Lastly, the semiautonomous nature of the sensory apparatus of the system is important to note. Describing the ability of octopus tentacles to react to stimuli in their environments, Hochner (2008: pp. R897–98) states:

"The optic lobes and arm nervous systems are connected to the brain by a relatively small number of nerve fibers. This suggests that they each send highly processed information to the brain and receive high-order commands and inputs from it. That is, much of the planning, computation and execution of stereotypic arm movements are conducted within the arm neural system itself. Accordingly, natural-looking arm extension movements can be generated in amputated arms. This organization may be an optimal solution for the motor control of highly redundant flexible appendages and for processing sensory information gathered by millions of receptors distributed on the arm's skin and suckers."

Referring again to Fig. 4, the personnel of the realm – the ecclesiastical and secular lords – were sensors able to move or order action with a high degree of autonomy, which freed the king to deal selectively with matters within his kingdom. Like an octopus's arms, the various authorities throughout the realm could be ordered to act by the king, but were also able to manage local governance without necessitating his routine involvment or oversight. In a highly distributed and far-flung system such as the Ottonian Empire, the ability of individuals or groups of individuals to act or react to stimuli in their environments without needing to wait for authorization or instruction from the king would be highly desirable. Thus, the Ottonian custom of disenfranchising royal power by delegating it to their nobles would in fact have helped empower the king by providing a system of order and jurisdictional control throughout the realm – but this would have been a system that did not necessitate his persistent presence or his constant input. That the system did not necessitate his constant involvment should not be taken to imply that the kings were disinterested in local affairs. To the contrary, in a very octopus-like manner, there was active communication between them and their agents, and opportunities for top-level engagement whenever deemed desireable or necessary.

How might this kind of system be represented in the sources? Perhaps the easiest place to see this in action is THIETMAR of Merseburg's *Chronicon*, written ca. 1012–1018 CE, which positively bristles with references to messengers passing between ecclesiastical and secular lords, as well as between those lords and the king. Additional formal assemblies and courts presided over by the king are frequently held as well. The king's interest in what was going on at a local level is suggested, for example, by instances such as when in 1005 Henry II issued a decree to a synod of bishops intended to address abuses in the church (1935: vi:18, pp. 295–296). While this suggests involvement in kingdom-wide issues via broad-reaching decrees, Henry's interest in specific local affairs is also indicated when he issued a capitulary try to bring localized violence between the residents of Worms and Lorsch under control (HENRY II 1900–1903: no. 501, pp. 640–641). That this intervention happened only after the local bishop had made his own attempts to bring the violence at Worms under control, ultimately issuing legislation of his own as well, suggests the nature of delegated local authority, with royal intervention when needed (BURCHARD OF WORMS 1893). THIETMAR'S narrative also indicates the importance of the right agents in the right places throughout its pages, evidenced through the frequent mention of the prerogative of the king to remove or replace those who were found somehow deficient in their duties.

Like the octopus, the Ottonians were adaptable, able to manipulate uncertainty, and maintained redundant and multifunctioning security. Like the octopus, Ottonian government was organized as an embodied intelligence, which allowed it to have those attributes of adaptability and redundant and multifunctioning security that were so essential to its success. Additionally, the Ottonians actively developed symbiotic relationships with real or potential rivals, for example, in their relationship with the papacy, or their efforts to Christianize the Slavs, or in Otto I's efforts in Northern Italy.

These octopus-like features of Ottonian government were not the only factors in their success, of course. But when combined with other aspects of their rule, such as the development of sacral kingship, a tentacular, distributed-neurobiological nature did contribute significantly to the strength and resilience of the infrastructure of Ottonian governance. And by viewing these characteristics as integral components of the governing structure as a whole, Ottonian rulership appears as a flexible and cohesive system of governance. The success of Ottonian rule was not accidental, it was not a fluke, and it did not happen despite a lack of a centralized organizational scheme. Ottonian rule was an organized system that worked to address the unique challenges of their political environment. It was a system that does not have any direct parallels in early modern and modern European paradigms of what effective government looks like, but it does mirror other kinds of effective systems for decentralized organization and adaptive defensive capacity – like that of the octopus.

Conclusion

The true value and adaptive capacity of decentralized biological systems are just beginning to be exploited by modern organizational strategists. Using those systems as a lens for examining Ottonian organization provides new perspectives and a better appreciation of their particular style of kingship. History and science have often had an uneasy relationship with each other. But the social and biological sciences do provide terminologies and models that are useful for describing specific ways that people or organisms interact with their environment. For example, Arnold (1997: pp. 137–139) has a chapter section entitled "The Symbiosis of the German Church and Medieval Kingship." Biologists are using economics to provide a framework by which to understand interactions in communities of bacteria (McGinty 2015). And in searching for metaphors for business organizational structures, Morgan (2006: pp. 33–114, 149–206) borrows from social science and biology when he discusses "Organizations as Organisms," "Organizations as Brains," and "Organizations as Political Systems," suggesting that all of these models have something to contribute to how we understand human organizational systems.

It is important to emphasize that all theoretical methodologies that we use to examine the past impose inherently artificial constructs onto that past. But that does not negate their value in helping to elucidate history. The study of systems, and biological systems in particular, suggests the potential utility of these systems as a constructive approach to the past. Applying not only the adaptive defensive and organizational systems that we see with the octopus but also theories of organization with regard to epidemiology, swarm

theory, and other methods of dispersion and self-organization to various historical problems may shed new light on them, or inspire new approaches to investigating them. At the very least, these new models may shake us out of conventional ways of thinking, helping historians look at old problems with fresh eyes and potentially break out of those patterns of thought that, no matter how self-consciously we approach our subjects, still color our perceptions of the past.

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