PART 2

Research Issues

CHAPTER 5

The Biology of Leadership

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Abstract

Scholars are beginning to recognize important biological elements that may influence those who move into leadership positions and who are effective in such roles (Arvey, Rotundo, Johnson, Zhang, & McGue, 2006; Balthazard, Waldman, Thatcher, & Hannah, 2012). Although consistent with the general "trait" model of individual differences as influencing leadership emergence and effectiveness, other biologically based influences also may play a similar role in determining those who move into and are effective in such leadership capacities. A growing literature on the role of biological factors has not yet been abstracted and summarized. It is the aim of this chapter to provide a succinct and useful summary of the various biological factors that have been identified as being associated with various leadership criteria and to provide directions for future research in these areas.

Key Words: leadership, biology, evolution, gene, environment, hormones, cognitive neuroscience

This chapter reviews literatures associated with a number of biological factors and research themes dealing with the topic of leadership. We cover research domains including evolutionary psychology; behavioral genetics; physical factors; hormonal, neurological, and brain functioning; and comparative studies with animals. This list represents a relatively large scope and although we wish to be comprehensive, our review is somewhat selectively narrowed due to the relatively small number of studies dealing with leadership issues across these domains. These areas of research often go unlinked, suggesting that such efforts are marching down their own, separate paths. As such, we attempt to find relevant connections and points of conversion. In addition, we deal with leadership that is defined rather loosely, as the term is typically used differently across the studies we review. Van Vugt, Hogan, and Kaiser (2008) considered leadership as both a resource for groups and an attribute of individuals, one whose primary significance concerns group performance. At a basic level, we use the term "leadership" as signifying one person exerting influence on followers to achieve certain kind of goals, but we also embrace the view that leadership is sometimes viewed as role-inherent. That is, people in formal management roles, in which they are supervising the work of others, are also considered "leaders" by nature of the power and authority invested in these "leadership positions." This notion is consistent with the view expressed by Bass (1990: 19), who says that people in such role positions "lead as a consequence of their status—the power of the position they occupy." This construal of leadership is also consistent with various empirical studies that define leadership from a role occupancy perspective. For example, Day, Sin, and Chen (2004) used the team captain position of professional (National Hockey League) teams as indicative of leadership role occupancy and studied the impact of role occupancy on later individual performance. The authors also pointed out that being appointed as an NHL team captain conferred special leadership privileges on those role occupants.

Why Examine Biological Processes in Leadership?

There is evidence that the recognition and incorporation of biological constructs and variables in theorizing and research in organizational behavior is mounting. Research is being published in top-tier journals about the role of genetics, hormones, physiological variables, evolutionary processes, and the like on organizational behavior (e.g., Arvey, Bouchard, Segal, & Abraham, 1989; Judge & Cable, 2004; Zyphur, Narayanan, Koh, & Koh, 2009). Thus, variables such as job satisfaction, vocational choices, decision making, and the like, which are somewhat under the influence of biological factors, are making their way into our literatures. This is not happening without resistance. **Colarelli and Arvey (in preparation)** make the observation that traditional scholars in the field of organizational behavior continue the tradition that organizational behavior can be "managed," working under mechanistic models of rationality, conscious, deliberation, and volition. The notion that biological elements could be involved somewhat violates this basic cognitive model of behavior. Moreover, most scholars maintained the belief that much of the variation in human behavior was due to environmental factors, such as developmental experiences and interventions, as well as to culture—what Cosmides and Tooby (1992) call the *standard social science model*. This model was developed out of the behaviorism model popularized by Watson in the 1920s (Watson, 1913, 1928).

Although it is now recognized that biological factors are indeed involved in organizational behavior, there is also a growing literature focusing on biological influences on the discipline of leadership. Such biological features may represent both barriers and enhancements in terms of one's likelihood of emerging as a leader and of being effective as a leader. Thus, our review summarizes these various biological features. It is important to recognize at the outset that we are not arguing that leadership is entirely due to biological factors. Indeed, the evidence presented will show that such factors are associated but, with a few exceptions, not highly coupled with leadership emergence and effectiveness.

Before we delve into a review of previous research, we discuss a question many people may ask: How can a biological perspective contribute to leadership research in general?

Leadership research has long recognized that a person's traits (e.g., general mental ability, personality, values, and physical features) play a critical role in leadership emergence and leadership effectiveness. Incorporating a biological perspective can enhance our understanding of the nature of the leader, the environment to which a leader is attracted and/or selected in (e.g., leadership experience), and how the leader and the environment interdependently shape leadership effectiveness.

First, a biological perspective of leadership can contribute to leadership research by promoting our understanding of the very nature of the person, beyond simply looking at leader traits. State-of-the-art technological developments in biology, neuroscience, and genetics allow us to tap into a leader's brain function, neurotransmitter activities, and genetic architecture. These new technologies have been widely used in such social sciences as economics, sociology, political science, and social and personality psychology. Leadership research can surely benefit from capitalizing on these developments.

Second, a biological perspective can also shed light on a deeper understanding of a leader's environment. For instance, research on leader development investigates how challenge experiences promote a leader's development of his capabilities. However, these challenge experiences are not entirely environmental: Leaders are likely to self-select or be selected into environments corresponding to their biological architecture. Incorporating a biological perspective could help tease apart biological influences on environmental factors and provide a deeper understanding of the relationship between putative environmental factors and leader development. Third, a biological perspective provides us ample opportunities to examine the interplay between the person and the environment in general. The notion that human behaviors are shaped by both the person and the environment has long been accepted in the organizational behavior area, yet extant research has predominantly used personality traits as a manifestation of the person. However, personality traits are also prone to environmental influence. A biological perspective, especially a molecular genetics approach focusing on the effect of specific genes, can carry forward the stream of research focusing on the interplay between person and environment. In the next sections, we review a range of biological approaches.

Evolutionary Approaches

It is a universal given that leadership positions exist and that these positions are filled by someone. Such leadership roles are required for the direction of and planning for "followers," for the swift execution of tasks, for the provision of resources, and more. Van Vugt, Hogan, and Kaiser (2008) and King, Johnson, and Van Vugt (2009) present evolutionary perspectives on leadership. These authors essentially reflect on two major issues: the origins of leadership (how did the need for leadership arise?) and the characteristics of individuals who move into these leadership roles. Both studies suggest that leadership arose in the context of both followers and leaders needing to adapt and compromise in order to maximize their gains for survival. For example, King et al. (2009) noted that cooperation and collaborations within animal or early human groups are of crucial importance for the efficiency and survival of the whole group, but that order is seldom acquired without a leader. Thus, King et al. (2009) suggest that the key to the emergence of leadership and followership was (and is) the need to coordinate and that the need for such coordination began quite early in the history of humans, who faced severe challenges from a primitive and dangerous world, and who needed to acquire basic resources (e.g., food, shelter, etc.). Game theory analyses are cited as supporting the need for coordination between leaders and followers. Because the need for leadership promoted the survival of our forbearers, it became part of our evolved psychology. Thus, there is almost universal societal recognition of the need for leaders and the acceptance of individuals who move into these roles.

Both King et al. (2009) and Van Vugt et al. (2008) outline the stages in human history for which different types of leadership existed to meet the conditions encountered in the environment. Van Vugt et al. (2008) describe four different stages (i.e., pre-human leadership (stage 1), band and tribal leadership (stage 2), chefs, kings and warlords (stage 3), state and business leadership (stage 4)) under which the kind of leadership involved differed substantially. King et al. (2009) suggest five major transitions in the evolution of human leadership: (1) leadership emerged in prehuman species as a mechanism to solve simple group coordination problems, in which any individual initiated an action and others followed; (2) leadership was co-opted to foster collective action in situations involving significant conflicts of interest, in which dominant or socially important individuals evolved as leaders; (3) dominance was attenuated to pave the way for democratic and prestige-based leadership to facilitate group coordination; (4) the increase in human group size created the need to select leaders based on powerful social and cognitive mechanisms; and (5) the increase in social complexity produced the need for more powerful and formal leaders to manage complex relationships. Another factor, of course, is the increased complexity of the technical environment surrounding humans in business settings; this created the need for cognitively smart and socially adept leaders. Of note is that particular environments in our history were salient with regard to the need for adaptation among our ancestors. This is an important ingredient in the co-evolution of situations and leadership.

King et al. (2009) and Van Vugt et al. (2008) also articulate the kinds of leader characteristics that are implicated in their evolutionary analyses. The typical suspects of personality traits (e.g. extraversion, dominance), social skills (e.g., perceiving the needs of followers), physical factors (i.e., height, weight, health), and motivation are suggested.

In summary, these two articles provide provocative perspectives on how leadership roles and the characteristics of leaders (and followers) evolved in the context of different situations. They pave the way for the rest of our chapter by providing a nice starting point and in laying a foundation for other literatures.

Animal Studies of Leadership

Much of the literature on human evolutionary processes refers to associated research on animals. The argument is that animal behavior was and is shaped by evolutionary processes, and similar processes were most probably operative for humans as well. The Discovery Channel and other media are replete with examples of the competition between males for mates, the role of dominance in the animal kingdom, and the like (although these accounts often describe competition for mates, rather than leadership).

The scientific literature also contains similar and fascinating material regarding leadership in animals. A variety of studies examine the phenomenon of leadership existence and of individuals exhibiting leadership among the species studied, as well as the factors that seem to be correlated with leadership. For example, a relatively early study by Allee, Allee, Ritchey, and Castles (1947) showed that there was some (but not complete) consistency in the leadership of a flock of white ducks, as indicated by which ducks generally were in front of others in going out the door of a duck house and going to food. Rabb, Woolpy, and Ginsburg (1967) observed the social organization of a group of wolves in an outdoor enclosure over several breeding seasons. They found the more dominant animals restricted the courtship activities of inferior wolves of their own sex.

Among some studies, personality factors, knowledge, and information, as well as environmental conditions appear to influence the likelihood of certain animals taking on leadership roles. For example, Kurvers et al. (2009) studied barnacle geese and showed that a leadership score (i.e., marking when the goose arrived at a food patch when matched against other geese) was significantly correlated with a variable called "novel object," which represented whether the goose would be relatively fast or slow in moving toward an object of unknown status. Other studies found that information could be crucial. Using minnows, Reebs (2000, 2001) showed that a small minority of informed individual fish would lead others to food at the right place and time of day and that such behavior was a function of body size and experience. Similar results were found by Leblond and Reebs (2006). Other animals such as elephants (Foley, Pettorelli, & Foley, 2008), ravens (Wright, Stone, & Brown, 2003), and hawks (Maransky & Bildstein, 2001) have been similarly identified as leaders as a function of being better informed and able to lead followers to resources. More generally, King et al. (2009: R912) observed that, across species, "individuals are more likely to emerge as leaders if they have a particular morphological, physiological, or behavioral trait increasing their propensity to act first in coordination problems." They remark that motivation, temperament, dominance, and knowledge are factors that increase the likelihood of individuals emerging as leaders among animal groups. Moreover, Hofmann, Benson, and Fernald (1999) studied the consistency of social status (measured by whether a fish was under threatening or nonthreatening conditions) among African cichlid fish as a function of changes in the environment, and their data indicated that changes in social status were a function of several underlying environmental conditions.

These and other articles generally provide evidence about leadership in the animal kingdom. Several themes fall out: (1) there is certainly evidence for leader–follower relationships; (2) particular individuals take on leadership roles; (3) some correlates exist between leadership and certain characteristics (i.e., body size, dominance, experience, etc.), although there is some evidence that the individuals that take on such roles are not always consistent across time and/or tasks; and (4) there appears to be some evidence that environmental factors influence which and when individuals take up leadership roles (e.g., environmental turbulence, particular task involved). These are also familiar themes in the literature pertaining to leadership among humans.

Genetic Factors

There are strong opinions regarding the degree to which leadership has a genetic basis compared to various environmental and developmental factors. For example, Sorcher and Brant (2002: 81) hold that "our experience has led us to believe that much of leadership talent is hardwired in people before they reach their early or mid-twenties." Conversely, Kellaway (2002) reports the efforts of a major bank to develop all of its employees (95,000 of them) into leaders, reflecting the belief that leadership is predominately influenced by developmental factors.

Methods to Examine the Genetic Influence

There is, however, growing evidence that genetic factors are associated with leadership. What was once an intractable problem of separating the impact of environments from genetic factors on particular variables of interest has now been solved via behavioral genetics methodologies using twin samples. The observation that talent or "leadership" runs in the family is frequently made, and there are certain well-known examples of this, particularly in political contexts (e.g., the Bush or Kennedy families). However, families have both common genetic endowments and common environments. The use of twin samples allows researchers to estimate the separate influences of both genetics and environments on observed or latent variables. Several methodologies are involved. The first method is to calculate the similarity of monozygotic (MZ) twins reared apart. Because this type of twins has 100 percent of their genes in common, but were raised in (presumably) different environments, a measure of similarity (i.e., the intraclass correlation coefficient) gives a direct estimate of the proportion of variance accounted for by genetics (or the heritability). Arvey, Bouchard, Segal, and Abrahams (1989) used this methodology to estimate the heritability of job satisfaction, showing that about 30 percent of the variance in overall job satisfaction can be accounted for by genetic factors.

Because obtaining samples of MZ (identical) twins reared apart is difficult, and such twin pairs are rare, an alternate methodology uses mono- and dizygotic (DZ, or fraternal) twins as samples. Because MZ twins hold 100 percent of their genes in common, whereas DZ twins hold on average only 50 percent of their genes in common, greater similarity among the MZ twins on the variable of interest compared to the DZ twins indicates that genetic factors are operative. The assumption here is that the twin pairs were raised in common environments (e.g., same father and mother, housing, income levels, etc.). This methodology basically allows for variation in the genetic makeup of the two types of twin pairs, but with a common shared environment (at least when growing up); conversely, in reared-apart twin studies, the variation is in the environment, with the genetic factors held constant. Examples of the use of this methodology are studies by Arvey, McCall, Bouchard, Taubman, and Cavanaugh (1994) on work values, and by McCall, Cavanaugh, Arvey and Taubman (1997) on job switching (see Ilies, Arvey, and Bouchard [2006] for a review of this research).

The assumption that MZ and DZ twins (within each pair) share a common environment (the equal environment assumption or EEA) is frequently challenged, and it is worthwhile commenting on this issue. There is some research testing the hypothesis that environmental similarity would affect twin similarity for the construct or behavior of interest. The issue is not necessarily that MZ twins experience more similar environments than do DZ twins, but whether such similarity is related to what is being studied. This assumption has been tested with personality. Borkenau, Riemann, Angleitner, and Spinath (2002) showed that MZ twins reported more similar experiences than did DZ twins but that treatment similarity was unrelated to personality resemblance. More relevant to the research on leadership reviewed here, using the male sample of MZ and DZ twins described by Arvey, Rotundo, Johnson, Zhang, and McGue (2006), Zhang (unpublished data analysis) found that although the MZ twins were indeed more similar when describing their parental environment than were DZ twins, this stronger resemblance was unrelated to any resemblance with regard to the leadership variable used in this study (leadership role occupancy). These data are consistent with the statement by Plomin et al. (2008: 79) that the "equal environments assumption has been tested in several ways and appears reasonable for most traits."

More sophisticated modeling procedures (structural equation modeling) now allow researchers to separate the factors that account for variance in a variable into three independent factors: *genetic factors* (A), the proportion of variance due to one's genetic background; *shared environmental factors* (C), the proportion of variance due to common influences from one's family and/or common experiences for both twins; and *nonshared environmental factors* (E), essentially, all possible exogenous events and developmental personal experiences that could influence the variable of interest. Behavioral genetics research has firmly established that almost every human attribute has some genetic influence (McGue & Bouchard Jr., 1998; Plomin, DeFries, McClearn, & McGuffin, 2008).

Several recent articles examine the influence of genetic factors on leadership. Before reviewing this literature, it is worthwhile understanding why there may be such a relationship. One helpful model is given in Figure 5.1, showing the potential pathways by which genes could exert an impact on leadership. This figure indicates that genetic factors may have both a direct effect on leadership, as well as operate indirectly through a variety of biological and psychological pathways. The question becomes: What empirical evidence is there for the role of genetics in relationship to leadership?

Evidence of Genetic Influences on Leadership

Several studies bear directly on this issue. An earlier study by Johnson, Vernon, McCarthy, Molson, Harris, and Jang (1998) used MZ and DZ twins to estimate the heritability of two leadership style measures—transformational and transactional leadership. Their results showed that, respectively, 48 and 59 percent of the variance of the transactional and transformational leadership measures were accounted for by genetic factors. A later study using these same subjects was reported by Johnson, Vernon, Harris, and Jang (2004) showing that a number of personality variables were likewise under considerable genetic influence and that the same genetic factors were involved in their influence on the leadership measures—a finding of genetic correlation. Another study examined the heritability of a particular personality variable—leadership potential—drawn from the California Psychological Inventory (CPI) comparing twins reared apart and twins reared together (Bouchard, McGue, Hur, & Horn, 1998). The data indicated that a substantial portion of the variance on this variable was heritable—about 49 percent.

Arvey, Rotundo, Johnson, Zhang, and McGue (2006) used 238 MZ male twins and 188 DZ male twins to examine the heritability of leadership role occupancy—that is, whether these individuals had

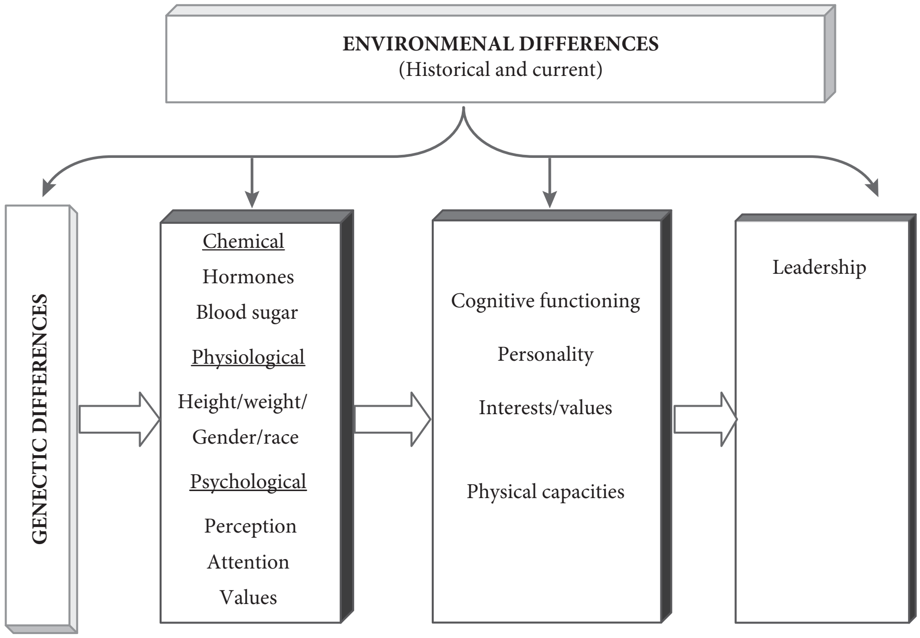

Figure 5.1. Pathways from Genes to Leadership.

moved up into leadership positions and the relative nature of these positions (i.e., whether they were in presidential, vice-presidential, director, supervisory roles). This variable is consistent with the definition of leadership having an "emergent" quality, in contrast to "leadership effectiveness" (see Judge, Bono, Ilies, & Gerhardt [2002] for an operational definition of these two broad types of leadership). The data indicated that the estimated genetic component on this leadership variable was 31 percent, whereas the remaining variance (69 percent) was accounted for by the nonshared environment. Interestingly, no influence was observed for the shared environmental factor, which is a consistent finding in the behavioral genetics domain—shared environment seems to play little or no role relative to genetic and nonshared environmental factors. Also measured were a number of personality variables (i.e., social potency, achievement) hypothesized to mediate the path between the genetic and leadership variables. Although both these personality factors were likewise shown to be under considerable genetic influence (54 percent and 43 percent of variance respectively), no mediation effects were detected due to low statistical power.

A similar study was conducted by Arvey, Zhang, Avolio, and Krueger (2007), this time using female twin samples. In this study, 178 DZ and 214 MZ female twins were investigated with regard to the heritability of leadership role occupancy. Findings were consistent with the previously cited male sample—a heritability of 32 percent was found. This study also examined more specifically what kinds of nonshared environmental factors were associated with the movement of these subjects into positions of leadership. Two broad general developmental factors were identified. One involved formal work experiences (e.g., training and development experiences, prior successes in leadership, unexpected opportunities), whereas the other factor was a more general family experience factor involving parents, siblings, and religious experiences. Although both these factors were correlated with the leadership role occupancy variable, when the genetic factor was parceled out, the work factor was significantly related to leadership role occupancy. Thus, this study suggests that, although people might attribute their success in becoming leaders to their families, their actual success might actually work through their common genetic backgrounds and developmental activities in work settings.

Using meta-analysis–derived correlations between the "big five" personality dimensions of emotional stability, extraversion, openness, agreeableness, and conscientiousness, and adding the dimension of intelligence, Ilies, Gerhardt, and Le (2004) estimated the genetic contribution to leadership emergence as mediated through these other variables. Their analyses indicated that approximately 17 percent of the variance of the latent construct of leadership emergence could be accounted for by genetics, as mediated through these personality and IQ variables. However, as noted earlier in other studies, the generally consistent value is about 30 percent, so other variables may also mediate the genetic–leadership linkage and/or there is a direct effect that is operative.

What is quite clear based on these studies is that a fairly powerful genetic component is associated with leadership emergence. However, equally clear is that environmental factors also play the major role in influence. Again, we do not argue a deterministic point of view on the part of "nature."[1]

Gene and Environmental Interplays

The finding that leadership has a fairly sizable genetic component is not particularly exciting at this stage of frontier research programs. As is evident from the literature abstracts cited earlier, recent research is looking at various, more complex models that incorporate both genetic and environmental factors.

The notion that there may be genetic and environmental *interactions* that are important to look at in studying leadership was suggested by Ilies, Arvey, and Bouchard (2006) and more recently by Zhang, Ilies, and Arvey (2009). Zhang et al. (2009: 118) state: "Apart from the main effects of genetics, the environmental and the developmental efforts stemming from the environment could have an active influence on the extent to which one capitalizes on his or her genetic endowments for leadership." Zhang et al. (2009) conducted one such study examining whether early family conflict (an environmental experience) would interact with genetic factors in influencing whether individuals moved into positions of leadership. They developed two possible scenarios: One possibility was that early conflict would act to allow greater genetic influence in leadership capacity; the other scenario was that a more benign (or enriched) early environment would permit greater genetic influence on later leadership emergence. Based on the same male twin sample used by Arvey et al. (2006), their data showed that, in terms of moving into leadership positions, genetic influences were weaker for twins reared in the more enriched family environments, but stronger for twins who had relatively poorer social environments. These data are consistent with those suggesting that challenge, adversity, and negative situations are the environmental developmental components that allow individuals to learn from these circumstances and become better equipped to move into leadership positions (e.g., Bennis, 1994; Coutu, 2002). A perplexing issue in examining such interaction is *which* specific component of the environment one should examine. There are an infinite number of specific environmental factors (e.g., work, family, school) that individuals experience in early and later life. What is needed is a better taxonomic system to further categorize such exogenous factors and to use theoretical frameworks to choose which to use in exploring such environmental–genetic interactions.

It is also useful to explore *gene–environmental correlations* in conducting further research on genetics and leadership. This posits the possibility that there may be a genetically based tendency for individuals either to seek out or avoid certain environments. At a broader level, Johnson (2007: 424) states that "the environment is not a unitary set of circumstances, and individuals' efforts to seek or create environments compatible with their genetic endowments are fundamental to the process of evolution." For example, it might be that individuals who are genetically predisposed to moving into leadership roles would seek out more challenging and complex work environments, whereas others who are not so predisposed might avoid such environments. Two studies looking at other workplace phenomenon demonstrate such a correlation. First, Arvey et al. (1989) showed that identical twins reared apart were working in similarly complex jobs—the heritability for job complexity was 0.44. Similarly, Hershberger, Lichtenstein, and Knox (1994) found descriptions of organizational climate, a variable thought to be almost entirely a function of environmental factors, was heritable. The upshot of this is that researchers must consider what kinds of environments individuals who become leaders are most attracted to. In addition, is it possible to engineer such environmental components early in development, so as to capitalize on these genetic tendencies for later movement into and effectiveness in leadership roles?

New Approaches to Study the Relationship Between Genetics and Leadership

Other types of designs incorporating longitudinal approaches could also have great value in studying genetic forces at play during developmental periods, and these kinds of designs have been used in other contexts. Although currently published findings on specific genes and their possible association with leadership variables are scarce, ongoing research does shed light on other variables often related to leadership. For example, the serotonin transporter gene 5-HTTLPR has been shown to be related to the stress resilience of individuals (e.g., Munafò, Brown, & Hariri, 2008). These findings lend support to promising future application of molecular genetics in leadership research. As a matter of fact, some initiatives demonstrating the value of molecular genetics in the organizational behavior paradigm are already under way. Song, Li, and Arvey, in their series of studies about molecular genetics and job satisfaction, have found some interesting results. One of their studies found statistically significant (although relatively weak) associations with job satisfaction between dopamine receptor gene DRD4 and serotonin transporter gene 5-HTTLPR, and that participants' level of pay mediated the relationship between DRD4 and job satisfaction (Song, Li & Arvey, 2011). A second study found the moderating effect of the DRD4 gene on the relationship between job complexity and job satisfaction. The relationship is stronger among people who have a larger number of the DRD4 7R gene. Also in this study, they found that job complexity partially mediated the relationship between the DRD4 gene and job satisfaction (Li, Song, & Arvey, unpublished). Meanwhile, another group of researchers has begun to investigate the genetic basis of leadership by combining twin studies with genetic association methodologies (De Neve, Mikhaylov, Dawes, Fowler, & Christakis, 2013).Thus, we expect more research examining specific genes and how they correlate—as well as interact—with other variables in influencing leadership.

Anthropomorphic Factors

If we borrow from evolutionary psychology and the comparative animal literature, we would suspect that a number of physical factors might be correlated with leadership. A number of studies have indicated positive relationships between various physical factors and leadership emergence and effectiveness. Bass and Bass (2008) provide a good review of many of these studies. The variables examined include height, weight, physique, health, athletic prowess, energy, and energy level.

With regard to height, accumulating evidence from general research suggests being taller has a number of positive outcomes for individuals. Bass et al. (2008) report a correlation of about 0.30 between height and leadership. A more recent meta-analysis by Judge and Cable (2004) showed that height was moderately correlated with leadership emergence (0.24) and leader performance (0.18), in addition to being significantly correlated with income and other psychological variables (e.g., self-esteem). Thus, although one cannot discount the potential impact of greater nutritional environments, the evidence clearly indicates a correlation between individual height and leadership.

When examining weight, some theorize that the relationships between this variable and a variety of success variables may differ by gender (see Judge & Cable, 2011). It is believed that, for males, those who weight more (up to the point of obesity) may be more successful than those who weigh less. For females, it seems that excessive weight is disadvantageous, but excessive thinness is disadvantageous as well.

Judge and Cable (2011) analyzed data from two large databases and generally confirmed the complex relationship of the impact of weight on income: Weight is generally positively related to income up to a particular weight level for men, and that weight is negatively related to income for women. However, we acknowledge here that the relationship between weight and income is probably much more complex than Judge and Cable's study claimed. Another study (Han, Norton, & Stearns, 2009) analyzed the same dataset (National Longitudinal Survey of Youth 1979) used by Judge and Cable (2011) but reached different conclusions. That study found a stronger negative relationship between body mass index (BMI) and wages in occupations requiring more interpersonal skills. For those beyond their mid-twenties, the negative relationship between BMI and wage is even stronger. Furthermore, they found that being overweight and obese tended to be associated with less income for all race–gender subgroups except black women and black men. Assuming leadership emergence is related to income, these results would probably generalize to the leadership domain.

Superior physique can also be an advantageous characteristic for leaders. Bass and Bass (2008) presented early studies showing small but reliable evidence for a relationship between physique and leadership variables. Most likely, such physical characteristics may facilitate leader role acquisition via the projection of a favorable image, although physique per se may not be specifically related to being a better leader. Studies show that people have stereotypes regarding particular body shapes (or "somatotypes"). For males, physical traits and strength are key factors in the evaluation of their masculinity and, subsequently, their fitness for leadership. For example, Gacsaly and Borges (1979) found that a well-muscled, sportsman-like body shape (a *mesomorph* body type in their study) was associated with more socially desirable personality traits, whereas a body build with more fat and less muscle (an *endomorph* body type) was associated with individuals who lack social skills as well as leadership capability.

According to a group of studies summarized in Bass and Bass (2008 [refer to p. 32]), leaders generally appear to be superior in health to nonleaders Early scholars (i.e., Stogdill, 1948) proposed that situational factors may be involved in the explanatory effectiveness of physical characteristics with regard to leadership. In situations where physical requirements are high, a relationship will be manifested. For example, in their study of male cadets at the U.S. Military Academy, Rice, Yoder, Adams, Priest, and Prince (1984) found significant positive relationship between physical fitness and leadership ability evaluations. Similarly, Atwater, Dionne, Avolio, Camobreco, and Lau (1999) tracked the leadership development of 236 males in a military college from matriculation to graduation and found that physical fitness measured early in the first year of college predicted leadership effectiveness in the fourth year.

Several studies present evidence that in boys' gangs and groups, athletic ability and physical prowess are related to leadership status (Bass & Bass, 2008). One later study by Atwater and Yammarinol (1993), studying midshipmen at the U.S. Naval Academy, found that athletic participation was an effective predictor of followers' ratings of transformational leadership.

A higher level of energy is also considered an important characteristic of leaders, who usually deal with heavy workloads (e.g., extensive travel, long hours.) and complex relationships. Five earlier studies summarized in Bass and Bass (2008) showed that those who emerge as leaders were generally characterized by high energy levels.

Another physical feature of interest to researchers studying leadership is physical appearance. In general, human beings show a preference for better looking faces. As early as infancy, such preferences are readily observable (e.g., Langlois et al., 1987). Physical attractiveness not only offers advantages in romantic relationships, but facilitates the acquisition of social status. Eleven studies reviewed in Bass and Bass (2008) found leaders to be better looking, although it should be noted that observed relationships between appearance and leadership are not unconditional. For example, students emphasize appearance more when choosing leaders for social activities compared to choosing leaders for intellectual and religious activities (Dunkerley, 1940). Furthermore, such a relationship may be more salient for boys than for girls in leadership contexts (Tryon, 1939). Moreover, facial appearance often serves to provide intuitive shortcuts for inferring individual competence in leader elections (e.g., Antonakis & Dalgas, 2009; Todorov, Mandisodza, Goren, & Hall, 2005). When asking a group of Swiss children to pick a leader from a pair of photos, Antonakis and Dalgas (2009) surprisingly found that children make predictions quite consistent with assumedly more rational and experienced adults. This may suggest that, as electors, we are subject to so-called *facial effects* more by nature than by nurture.

Appearance may also function differently under different conditions. Mazur et al. (1984) found that facial dominance of West Point cadets had a substantially positive relationship with cadet rank while at West Point but a weaker positive relationship with rank in military service 30 years later. Livingston and Pearce (2009) also showed that, despite its stereotyped correlation with immaturity and lack of competence, having a "baby face" nonetheless benefits black CEOs, as a "baby face is disarming" and makes them seem more trustworthy. Another interesting study showed that people prefer leaders to have more masculine faces when imagining their nation is under threat of war, whereas they are more accepting of feminine faces when imaging the nation in peace-keeping roles (Spisak, Homan, Grabo, & Van Vugt, 2012)(Brian, Homan, Grabo, & Van Vugt, 2012). Despite the specific conditions in which the criteria of a preferable appearance may differ, the research evidence generally supports a relationship between appearance and leadership.

Endocrinology and Leadership

The endocrine system is made up of glands, each of which secretes a type of hormone into the bloodstream to regulate the body. Hormones are chemical mediators released from endocrine tissue that allow communication among cells and regulate many functions of an organism, including mood, growth and development, tissue function, and metabolism. Hormones generally act more slowly in controlling biological processes compared to their activity in the nervous system (Brown, 1994), but the endocrine system usually interacts closely with the nervous system. The study of such interactions is called *neuroendocrinology*. Neurotransmitters are mainly responsible for transmitting neural information.

Several types of important hormones and neurotransmitters are considered to demonstrate reliable influences on a variety of social behaviors and have been widely studied. Here, we focus on studies concerning testosterone, serotonin, and oxytocin as they pertain to leadership. Some of the studies bear directly on the issue of leadership; others may not concentrate on this specific topic but offer meaningful findings contributing to the growing literature in this area of leadership research. Our choice of these three particular hormones was guided simply by the number of previous studies showing relationships between them and other social behaviors associated with leadership (e.g., dominance).

Testosterone

As Anderson et al. (2007) noticed, testosterone (T) has received the most attention among potential hormones or neurotransmitters that may be antecedents of dominance (a particularly reliable correlate of leadership). Testosterone is the androgen (male sex hormone) that relates to the development and maintenance of masculine features, and it is found in both males and females (Brown, 1994). It has been associated with dominance, status seeking, aggressive behaviors, and sexuality in a wide range of studies, although inconsistent findings exist. Males generally have seven times as much serum T as do females (Mazur & Booth, 1998), and three times as much in saliva (Granger, Shirtcliff, Booth, Kivligham, & Schwartz, 2004). Nonetheless, it has been shown that T has a similar impact on psychological and behavioral outcomes in both sexes when controlling for gender (Josephs, Newman, Sellers, & Metha, 2006). It has also been shown that T levels have a rather high heritability (0.40) (Meilke, Stringham, Bishop, & West, 1987), indicating that there may be a persistent and stable difference among individuals regarding their observed T levels. Compelling evidence has documented an association between testosterone and dominance using both animal and human subjects. The association between T and dominance is observed in primates with a more developed social structure, such as rhesus macaques (Rose, Holaday, & Bernstein, 1971), squirrel monkeys (Coe, Smith, Mendoza, & Levine, 1983), mountain gorillas (Robbins & Czekala, 1997), bonobos (Marshall & Hohmann, 2005), and chimpanzees (Anestis, 2006; Muehlenbein, Watts, & Whitten, 2004).

Similar influences of T on dominance and status seeking in humans have been shown in a large collection of studies (Archer, 2006; Mazur & Booth, 1998). Testosterone also has been shown to effect motivation to gain power and social dominance (Gray, Jackson, & McKinlay, 1991; Sellers, Mehl, & Josephs, 2007) or make one alert to status threats (Josephs, Newman, Brown, & Beer, 2003; Schultheiss & Brunstein, 2001). Boys recognized by peers as leaders have higher basal T levels (Rowe, Maughan, Worthman, Costello, & Angold, 2004). Within the context of organizational settings, T was found to be related to higher status positions in occupations (Cristiansen & Knussman, 1987; Purifoy & Koopmans, 1979).

Another piece of evidence about the relationship between T and leadership comes from studies on the ratio of second-to-fourth–digit length (2D:4D), which is considered a marker for the concentration of prenatal testosterone relative to estrogen. One study found that those with lower 2D:4D ratio (an indication of higher prenatal T concentrations relative to estrogen) had stronger preference for an enterprise career orientation, which is characterized by management, organizing, trade, and leadership (Weis, Firker, & Hennig, 2007). Another study also reported that a lower 2D:4D ratio was related to higher perceived dominance and masculinity for males (Neave, Laing, Fink, & Manning, 2003). A recent study by Zyphur, Narayanan, Koh, and Koh (2009) revealed that, rather than being a direct predictor, T level may play a more implicit and subtle role at the basic psychological level. Their results showed that whether members end up with a higher status in a group is not necessarily related to their T levels, but that a greater mismatch between T levels and status can lead to lower collective efficacy for the group.

Notwithstanding the large volume of studies on T, several issues are still in contention. These include:

1. *Is there is a direct causal relationship between T and dominance?* Some evidence suggests reversed or reciprocal relationships. For example, Rose, Berstein, and Gordon (1975) found that not only did T levels predict dominance, but that changes in dominance or social status also affected T levels.
2. *Are dominance and aggression affected similarly?* Mazur and Booth (1998) favored the hypotheses that T level has a more direct relationship with dominance than aggression. This may be a more reasonable hypothesis for humans, for whom being dominant is much more complex than simply being strong and aggressive, as in many animal species.

3. *What are the conditions under which T and dominating behavior is aroused?* Interesting studies have suggested that T level may increase under perceived social hierarchy instability (Josephs, Newman, Brown, & Beer, 2003; Josephs et al., 2006) or when facing challenges, as was predicted by the challenge hypothesis (see Mazur & Booth, 1998).

4. *Do other hormones in combination with T affect dominance?* Mehta and Josephs (2010) recently found that T was positively related to dominance, but only in individuals with low cortisol. Such studies are informative because studies of single biological factors usually have difficulty in consistently explaining or predicting phenomena.

Serotonin

The neurotransmitter serotonin also has been related to aggression and establishment of social status. Serotonin shows important functions in regulating emotions, eating behaviors, biological rhythms, behavioral arousal, and motor activity (e.g., Challet, Pévet, & Malan, 1997); pathologically, it is involved in a range of emotional disorders including anxiety, stress, depression, and schizophrenia (Dinan, 1996a, b; Graeff, 1997; Graeff, Guimarães, De Andrade, & Deakin, 1996). Anderson and Summers (2007) discuss the serotonergic system and its possible relevance to leadership, proposing that any relationship exists mainly through the serotonergic regulation of mood and aggression. They presented studies showing that both serotonin and T actively influence aggression through anterior hypothalamus, by acting on vasopressinergic cells. Human studies are very rare in this area. Madsen (1985) proposed that whole blood serotonin (WBS) was related to power seekers and type-A personality behavior patterns, but his methods were criticized as suffering from conceptual imprecision and improper operationalization (Vatz & Weinberg, 1991). Although much progress has been made in studying the functions of serotonin, questions about a serotonin–leadership relationship remain largely unanswered, especially for human beings.

Oxytocin

Dominance and aggression may facilitate leadership emergence in some situations. Nonetheless, trust and the feelings of attachment also play important roles in the development and maintenance of relationships among social animals, including human. And relationships between leaders and followers are no exception. Trust and attachment are key concepts in important leadership areas such as transformational and charismatic leadership (e.g., Dirks & Ferrin, 2002; Kirkpatrick & Locke, 1996; Popper, Mayseless, & Castelnovo, 2000). Transformational leaders usually show keen interest in followers with emotional investment. They value trust and have positive models of both themselves and others in an attachment relationship.

There are apparent individual differences in the tendency to become a transformational leader, and it is of great interest to review which biological factors may influence key components of transformational leadership, such as trust, empathy, personal consideration, and attachment. Kosfeld et al. (2005) showed that oxytocin may be part of the biological basis of trust among humans, considering its important role in social attachment and affiliation in nonhuman animals. They found that intranasal administration of oxytocin causes a substantial increase in trust. Particularly, oxytocin has no effect on a general increase in the readiness to bear risks, but specifically affects the willingness to bear social risks through interpersonal interactions. Oxytocin is also related to trustworthiness between humans (Zak, Kurzban, & Matzner, 2005), and higher oxytocin levels are associated with trustworthy behavior or others' intention to trust. In addition, oxytocin was also related to empathy and attachment, or affiliative behaviors (e.g., Hurlemann et al., 2010; Insel & Young, 2001). Thus, we may tentatively infer that leaders with higher levels of oxytocin may be more likely to consider building and maintaining trust an easy and comfortable task, and that the empathy abilities associated with oxytocin also enable the leader to stand in the shoes of subordinates. In turn, subordinates aware of the leader's benign intentions would be more willing to put their trust in him or her, according to Zak et al. (2005). In addition, oxytocin is also involved in stress reduction. For example, oxytocin can mediate the effects of social supports in reducing psychological stress in humans (Heinrichs, Baumgartner, Kirschbaum, & Ehlert, 2003).

Unfortunately, despite the exciting fact that social behaviors associated with oxytocin have important implications in leadership research, we are not aware of any study investigating the possible association of oxytocin and leadership styles. Thus, we can only propose that some interesting relationships may exist, but more theoretical and empirical efforts are needed to verify them.

Cognitive Neuroscience and Leadership

The *Annals of the New York Academy of Sciences* devoted an entire issue (no. 1118) in November 2007 to discuss social cognitive neuroscience in organizational studies, thus implicating the value of this emerging area of interest in organizational paradigms. In their recent review, Senior, Lee, and Butler (2010) offer further illustrations about the organizational cognitive neuroscience (OCN) perspective, the research benefits of using OCN, and the techniques that organizational cognitive neuroscientists may use. In discussing the application of neuroscience to leadership research, they mention that, although certain leadership traits are heritable, recent finding in mice showed that through training and learning processes parts of the brain may engage in functional reorganization (Yin et al., 2009). Thus, cognitive neuroscience may help to resolve the debates on how much of leadership is influenced by nature and how much by nurture. Moreover, by integrating cognitive neuroscientific knowledge about other interesting variables, such as creativity and empathy, we may come to know more about what constitutes leadership (Senior, Lee, & Butler, 2010).

Conversely, as Senior et al. have noted, few organizational researchers have applied cognitive neuroscience within their research models. Consequently, possible connections between leadership research and neuroscience are rather implicit. In addition, direct linkages are also less likely to be found due to the complexity of the leadership phenomenon. Thus, a better strategy is to decompose leadership variables and explore the neural basis for the key elements. We first talk about decision making. This important topic is of mutual interest in both leadership and neuroscience studies, and there are also relatively more studies available inthe area of cognitive neuroscience. Then, we introduce some recent studies that explore the neuroscientific explanations of leadership.

Before discussing those specific topics, it is worth mentioning that Senior et al. (2010) provided concise and comprehensive instructions about the techniques that organizational cognitive neuroscientists can utilize. The relatively common techniques are electro- and magnetoencephalography (EEG and MEG) and functional magnetic resonance imaging (fMRI). In their review, Senior et al., using an illustration, show how each technique is placed in its unique area according to limitations of spatial resolution (the size of the minimum area of brain activity measurable) and temporal resolution (the time it takes to record a measurement). EEG and MEG are superior in their depiction of temporal resolution; fMRI has relatively poor temporal resolution but very high spatial resolution, which makes it a popular technique. Other available techniques, such as electrodermal activity (EDA) and transcranial magnetic stimulation (TMS), are also discussed in their review. Refer to Senior et al. (2010) for more information.

Decision Making

Decision making is a major task of particular importance in situations of risk and uncertainty. Leaders are often challenged to make risky choices and decide how various choices might benefit or harm their organizations. Real-life observation show abundant evidence that leaders vary in their tendency and style of risk taking and decision making. As to the neural basis of decision making, neuroeconomic researchers are blazing the trail with remarkable findings. People generally tend to avoid risky options involving a potential loss until the gain is at least twice as much as the loss, a phenomenon known as “loss aversion.” In risky choice studies, a consistent finding is that increased activity in insular cortex (a part of the cerebral cortex that regulates perception, motor control, self-awareness, cognitive functioning, and interpersonal experience) accompanies higher risk outcomes (Platt & Huettel, 2008), and people who score higher on neuroticism and harm avoidance also have the greatest magnitude of insular activation. When insular activity is higher before a decision is made, one may make an inferior choice to ensure safety even when the risky choice was actually a superior choice and in situations where such behaviors are maladaptive (Kuhnen & Knutson, 2005).

For leaders as well, when facing challenges and uncertainty, it might not always be effective to adhere to the safest strategy. Making decisions not only involves identifying risk, but also evaluating reward probabilities. It is usually difficult for leaders to obtain the complete information necessary, and they must learn how to make a choice under conditions of ambiguity both by analysis and trial and error over time (Platt & Huettel, 2008). The medial prefrontal cortex[2] has been proposed to be associated with subjects’ learning about uncertainty by trial and error (Elliott & Dolan, 1998; Schubotz & von Cramon, 2002). Platt and Huettel (2008) also mentioned other brain regions that may be associated with selection of behaviors under uncertainty. For example, insular, lateral prefrontal, and parietal cortices show increased activation under high uncertainty when a probabilistic classification task is based on the relative accumulation of information between two choices. These regions also overlap with the neural control systems involved in behavioral control and executive processing. Fellows (2004) proposed that frontal lobe plays an important role in decision making, according to evidence from lesion studies[3], such that a less functional frontal lobe leads to impaired decisions. Another study indicates that genetic variation in the serotonin transporter gene (5-HTTLPR) may mediate bias in decision making, in that the genetic variation is associated with altered amygdala[4] reactivity and lack of prefrontal regulatory control, which in turn is related to people's susceptibility to context and risk while making decisions (Roiser et al., 2009).

These studies are rather selective, given the large volume of neuroeconomic studies in decision making, yet they are helpful in giving organizational researchers a sense of the current findings on decision making, as well as possible ways to conduct such studies. Understanding how the brain functions in decision-making processes is valuable in estimating and predicting how leaders make their decisions. Moreover, neuroscientific findings about decision-making efficiency in leaders may offer tests of leadership development efforts. If some learning processes do involve neural reorganization, such research would provide a valuable guide for more elegant development program designs.

Emerging Efforts in Leadership Neuroscience

A group of researchers from Arizona State University has tried to understand the distinguishable features of effective leaders' brain functions by using quantitative electroencephalographs (qEEG). In their recent review, Waldman, Balthazard, and Peterson (2011) **reported their study by** conducting qEEG assessments for 50 senior leaders from a variety of industries and they found that right frontal brain coherence[5] predicted leaders' behavioral charisma, as perceived by followers. This process was likely to be mediated by *socialized visionary communication*, which is an important feature of charismatic or transformational leadership. The activities of the right frontal brain, according to these researchers, is linked to emotional control of balance, foresight or "big picture" thinking, and insight. The authors believe that enhanced right frontal coherence may help individuals to be more flexible and insightful when balancing multiple concerns in the formation of a more socialized vision and to effectively deal with possible emotional strains and uncertainties.

Although neuroscientists may not reach agreement about the functions of the right frontal portion of the brain, and charismatic leadership can involve more complex cooperation of different parts of the brain, their findings are still informative and encouraging. Accumulated research efforts, especially those with reasonable theoretical guidance and supportive evidence, are necessary before any final conclusion can be reached.

Effective leaders interacting with individuals, groups, and organizations in dynamic environments are assumed to possess certain level of cognitive and affective complexity. Thus, in another research project, researchers (Hannah, Balthazard, Waldman, Jennings, & Thatcher, 2013) were interested in what constitutes complex adaptive leadership. They used qEEG to detect the brain activity of military leaders differing in psychometric assessments of self-complexity, and some preliminary results seem to suggest that observable differences in certain areas of the brain are related with high or low self-complexity. Moreover, these researchers are attempting to determine the usefulness of neurofeedback, which depends on an operant conditional procedure by which individuals can modify their neurophysiological activities, in the development of leadership ability. Although this brain training technique for leaders sounds like science fiction, it is a brave move forward. Interested readers are referred to Waldman, Balthazard and Peterson's (2011) review about inspirational leadership and neuroscience, which offers a detailed summary of their current research effort.

Other Neurological Findings Related to Leadership

In addition to discussions on leadership skills and their neurological basis, some interesting findings in neurologic studies about status-seeking motivation are worth mentioning. For example, a recent study using fMRI found that ventromedial prefrontal cortex (VLPFC) showed increased signals to higher status cues, relative to neutral and low status cues (Marsh, Blair, Jones, Soliman, & Blair, 2008). Zink, Tong, Chen, Bassett, Stein, and Meyer-Lindenberg (2008) found that viewing a superior individual was related to activity in dorsolateral prefrontal cortex. They stated that in unstable hierarchical settings additional regions (such as amygdala) relating to emotional processing, social cognition (medial prefrontal cortex), and behavioral readiness are recruited. Awareness of being at a lower status can cause stress. In vertebrates, stress hormones mediate such influence and eventually have physical consequences on immune and brain systems, including neurogenesis[6] (Robinson, Grozinger, & Whitfield, 2005). These studies help explain status-seeking motivations as being driven by neurological regulation.

Conclusion

This chapter has wound its way through a wide variety of topics and literatures. Although diverse, several important conclusions can be made:

1. There is abundant evidence that biological factors are clearly associated with a number of different leadership variables.
2. These associations are probably based on different kinds of direct and indirect mediating processes (e.g., through cognitive processes, personality, etc.).
3. Even though the evidence for the relationships between biological factors and leadership is strong and compelling, the environment is clearly more strongly associated.
4. There are good arguments based on evolutionary explanations as to why various biological factors demonstrate such associations.
5. The interplay between environmental and biological factors is complex, but will most likely provide a more comprehensive and accurate account of leadership.

Given the plethora of previous research on biological features reviewed and the broad concept of leadership, it seems difficult to give specific directions for future research. Thus, we offer only five general directions that we believe would be fruitful future research adopting a biological perspective, while we acknowledge there may be other promising avenues. We hope our suggestions stimulate more interest in the relationship between biology and leadership (and organizational behavior in general).

1. Future research should continue to examine associations between biological features (e.g., specific genes, hormones, and brain functions) and leadership. We view these types of association studies as a first step toward incorporating a biological view of leadership that shows the "main effect" of biological features.
2. Researchers should examine the pathways/mechanisms through which biological factors influence leadership. For instance, do specific genes shape leadership emergence by modulating protein formation, hormone activities, brain functions, and personality traits?
3. Researchers should investigate how biological features and environmental factors jointly (i.e., through interactions) influence leadership and the interactive effect of biological factors.
4. Researchers should conduct longitudinal studies to unpack more nuanced relationships among biological factors, the environment, and leadership. For instance, how do environmental influences modulate the expression of specific genes, signal feedback to the endocrine system, and adjust brain functioning over time? How do biological features and environmental forces interdependently influence leader development in the long run? How do genetic architecture and culture co-evolve in the emergence of a social hierarchy?
5. From a practical perspective, it would be helpful to generate evidence to support the notion that biological factors can be targets of intervention to promote leadership effectiveness. We believe endeavors in all of these directions can push forward our knowledge about leadership.
6. Finally, it is interesting to consider if similar factors are involved in "followership." That is, are the biological factors associated with who becomes a leader also involved in determining who is a follower?

It is time to get on with the pursuit of research that focuses on biological processes and how they influence leadership, a new paradigmatic approach that needs to be explored much more fully.

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Notes

1. Even highly heritable factors can be modified by environmental intervention. For example, eyeglasses and surgery can "correct" for poor vision, which is highly heritable.
2. Medial prefrontal cortex is a part of the brain cortex that is located in the frontal lobe.
3. A classical method to understand the functions and dysfunctions of the human nervous system by studying patients with deficits that follow specific brain damage.
4. The amygdala is an almond-shaped group of nuclei located deep within the medial temporal lobes of the brain. It has been found to perform a primary role in the processing and memory of emotional reactions.

5. According to the authors, coherence here refers to the strength of connectedness between various regions of the brain.
6. The concept of neurogenesis refers to the process by which neurons are generated.

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