The purpose of this paper is to review theory and research (i.e., evidence) regarding the science of team leadership. In accomplishing this objective, I will first provide a brief review of the evolution of the study of leadership to understand what changes have occurred, provide an understanding of which leadership approaches are active and inactive among researchers, and to identify the place that team leadership takes among contemporary leadership theories. There is also a robust literature on team science that will be reviewed briefly, mainly to highlight how leaders might intervene effectively in team processes, while also understanding that there are different kinds of teams that might require different leadership forms. The paper will conclude with practical recommendations for further development of a science of team leadership as well as to identify gaps between what is known and what we need to know to develop effective leadership for science teams (i.e., what are the existing research needs in the area).

Overview of Leadership Approaches

There is over a century of leadership theory and research that provides a solid foundation of evidence on which to make practical recommendations in helping leaders maximize their effectiveness. But this evidence is not completely coherent because of the historical battles attempting to prove the “right” theory of leadership. As a result, the leadership literature has offered a number of different theories or approaches that have waned and fluxed over time in terms of the interest that each has generated as well as the body of evidence that has accrued (see Figure 1). As noted by other researchers, the majority of leadership research holds little direct relevance for the focal topic of enhancing leadership in science teams (Kozlowski & Ilgen, 2006). Nonetheless, team leadership is emerging as one
focus among contemporary leadership theories that have active interest. In looking at these leadership approaches as well as the place that team leadership takes among them it will be noted where there are areas from general leadership theory that might further inform the emerging field of science team leadership, as well as where there are areas of disconnection.

**Figure 1: A Brief History and Look into the Future of Leadership Research**

![Figure 1: A Brief History and Look into the Future of Leadership Research](image)

*Note. From Day and Antonakis (2012).*

**Trait School of Leadership.**

The origins of the scientific study of leadership began around the turn of the twentieth century with the so-called great man or trait-based perspective. This school of thought suggested that certain dispositional characteristics (i.e. personality traits) could differentiate leaders from non-leaders as well as distinguish effective from less effective leaders. Interest in this particular leadership approach has ranged from being highly active to completely inactive and now back to very active (see Figure 1), mainly due to the advent of the widely accepted Big Five personality taxonomy as well as the emergence of meta-analysis as a
preferred method of evaluating results across studies (Day, 2012; Day & Zaccaro, 2007). Although we know that there are some traits that are associated with leadership perceptions and emergence (e.g., intelligence, extraversion, and to some extent conscientiousness), there is little available research about how leader traits are related to leadership effectiveness especially within team contexts. This approach also leads to somewhat of a dead-end if the core focus is on leader development. After all, if personality traits are thought to be relatively enduring dispositional characteristics then there is little that can be done to change them. At best, the trait school of leadership might be most relevant for leader selection purposes; however, most of the evidence for this leadership approach is around leader emergence (i.e., who is seen as a leader) rather than leader effectiveness (i.e., who performs most successfully as a leader).

**Behavioral School of Leadership**

Beginning in the 1950s, researchers began focusing on the behavioral styles of leaders mainly as a result of dissatisfaction with advances in the trait approaches to leadership (Day & Zaccaro, 2007). Influential studies conducted at the Ohio State University identified two overarching leadership factors generally referred to as consideration (i.e., supportive, person-oriented leadership) and initiating structure (i.e., directive, task-oriented leadership). A purported advantage of the behavioral approach is that it focused on observable leader behaviors rather than something less accessible such as personality traits. This was consistent with the corresponding rise of behaviorism as a dominant paradigm in psychology around that same time.

With one notable exception (Judge, Piccolo, & Ilies, 2004) this approach is not considered to be active today in terms of ongoing research; however, many of the ideas advocated by the behavioral movement have been incorporated into other perspectives of leadership, especially transformational leadership theory (Bass & Riggio, 2006). But it is also
the case that behavioral functions are at the core of functional approaches to team leadership (e.g., Morgeson, DeRue, & Peterson, 2010) that will be reviewed subsequently in this paper. Another interesting development that can be seen as an offshoot of behavioral approaches to leadership is the popularity of leadership competency models in organizations. The practice of competency modeling is controversial (see Hollenbeck, McCall, & Silzer, 2006) and the evidence is not clear-cut in terms of how much value leadership competency models provide to organizations. But what competency models do is to summarize core behaviors that are thought to be needed for effective leadership in a particular organizational context. One challenge with developing leadership competency models is that they need to be organizationally specific to provide a sustainable competitive advantage (Ulrich & Smallwood, 2007). Unfortunately, such models tend to be overly generic in focus, which detracts from their potential organizational value. Although the behavioral schools of leadership are not generally considered to be active with regard to current research, they do seem to have a lasting influence on leadership practice through competency modeling as well as through the advent of functional approaches to team leadership.

Contingency School of Leadership

A basic tenet of contingency approaches to leadership is that leader behavior must be matched with appropriate aspects of a situation in order to maximize outcomes and leadership effectiveness. This is no longer an active leadership approach in terms of ongoing research; however, it has contributed to the development of broader contextual approaches to leadership of which team leadership is one of those (reviewed in more detail below). An emerging theme in this review of prominent leadership approaches is that whereas there have been changes in focus over time, and that some approaches like the contingency and behavioral schools of leadership are no longer very active, they have been important influences on the development of the nascent field of team leadership.
Relational School of Leadership

The origins of relational approaches to leadership can be found in the literature on leader-member exchange (LMX), which describes the nature of the relationships between leaders and their followers. Research has shown that those followers who negotiate high quality exchanges with their leaders experience more positive work environments and are associated with more effective work outcomes (Gerstner & Day, 1997). LMX research in particular is a very active leadership research field with potentially important implications for team leadership. If relationships are important – as the LMX field has generally indicated – then it seems relevant that team leaders consider the exchange qualities that are developed with various team members. There is also fairly recent research on differentiated LMX, which pertains to the effects of having relatively consistent or differentiated relationships with followers in a workgroup. The results generally suggest that differentiated exchange qualities create difficulties in a workgroup that lead to less effective outcomes (Erdogan & Bauer, 2010; Wu, Tsui, & Kinicki, 2010). Nonetheless, this is a potentially relevant area of importance for team leadership that has not received a great deal of attention to date. Most of the LMX research has been conceptualized mainly at a dyadic level and only recently have researchers begun to note the importance of differential relationships between leaders and multiple followers within a given team context.

One area in which LMX has been shown to be important with regard to team leadership is how leaders shape the interpretation of team climate (defined as shared perceptions of group environment), especially for those members in which they have a high-quality exchange. In early research in this area, Kozlowski and Doherty (1989) demonstrated that team members with good exchange quality relations held climate perceptions that were similar to those of the leader and also consistent with each other relative to those with poor LMX relations. Subsequent researchers have replicated and extended these findings showing
that the exchange qualities enacted with team members helped to shape the nature and strength of climate perceptions (e.g., Hofmann, Morgeson, & Gerras, 2003). Thus, LMX relationships have important implications when it comes to shaping team members perceptions of their shared environment.

The New Leadership School (Transformational and Neo-Charismatic Leadership)

At a time when scholarly interest in leadership research was at a very low point researchers promoting different leadership approaches focusing on styles considered to be transformational, charismatic, and visionary brought new life to the field. Indeed, it remains one of the most active areas of leadership research. What is different about this approach is the focus on different leadership styles or behavioral tendencies that induce followers to transcend their interests for that of a greater good (e.g., transformational leadership). Charismatic leadership and its variants are typically categorized under neo-charismatic headings make up the single most dominant leadership paradigm over the past decade, although the relative influence of this perspective appears to be diminishing (Day & Antonakis, 2012). Ironically, whereas transformational leadership should be of particular relevance to teams it has been studied mainly (but not solely) at the individual level. There is recent research that has shown the multilevel and cross-level influences of transformational leadership to the effectiveness of innovation teams (Chen, Farh, Campbell-Bush, Wu, & Wu, in press). But for the most part the general research approach has examined how transformational leaders influence followers and outcomes at an individual level of analysis.

Contextual Approaches to Leadership

An active area of leadership research is the so-called contextual approaches to leadership. This is not a single approach but rather a collection of approaches that are examining leadership requirements within unique contexts. For example, there is been recent attention on leadership in extreme or dangerous contexts (Hannah & Parry, in press; Hannah,
Uhl-Bien, Avolio, & Cavaretta, 2009) as well as Presidential leadership (Simonton, 2013). Another leadership context that is of recent interest is that of teams. One such topic is that of shared leadership, which has attempted to shift the focus from leader-centric perspectives to how leadership roles, functions, and behaviors might be shared among people on a team. Research in this area suggests that it is not an either/or proposition (i.e., either traditional, hierarchical leadership or shared leadership). Rather, the best outcomes tend to be associated with teams that engage in both hierarchical as well as shared forms of leadership (Ensley, Hmielski, & Pearce, 2006; Pearce, 2004; Pearce & Sims, 2002).

Another approach within the contextual, team leadership literature is to focus on the leader as completer (e.g., Morgeson, et al., 2010). This perspective views the role of a team leader as doing or getting done whatever is not being handled for group needs. The sources of leadership in teams can be from either internal or external sources as well as formal or informal in terms of the leader’s role. Perhaps the most common source of team leadership is internal and formal, where there is a formally appointed team leader, project manager, or other individual who has formal responsibility for the leadership functions in a team. Another possibility that is gaining research attention is leadership that is internal and informal such as shared or emergent forms of leadership in which different individuals take responsibility informally for either different functions or for leadership at different times. External forms of leadership can either be formal such as a designated coach or team advisor or informal in terms of a mentor or champion. Whereas these external forms may be influential in shaping team success (Hackman & Wageman, 2005; Morgeson, 2005), the internal forms of team leadership seem to be where researchers have focused to date.

As will be discussed in subsequent sections of the paper, a way forward in terms of taking these perspectives on team leadership into practice is not to limit focus on a particular form of team leadership but to understand ways in which more traditional and hierarchical
leadership can be used in conjunction with more participative, shared, or otherwise emergent forms of leadership (i.e., blending formal with informal sources of team leadership). The relevance of both forms of leadership to science teams will be discussed in the next section.

In summary, this section has attempted to provide a focused overview of various leadership approaches that have potential relevance to the science and practice of team leadership. Thus, not every leadership school or approach was reviewed; however, the focus has been on those approaches that appear to have shaped team leadership research and theory or hold the most promise for further developing a science of team leadership. For this reason, other active leadership approaches such as the information processing and evolutionary/biological approaches were not discussed. Whereas team leadership is gaining research attention, it is generally considered to be one type of the broader category of contextual approaches to leadership. The leadership of science teams is even a smaller part of that overall context. The next section of this review paper will focus on providing an overview of team science and some of the particular nuances of teams, especially science discovery teams that have implications for understanding effective leadership within the basic science context.

Overview of Team Science and Team Leadership

There is more than 50 years of psychological research spanning thousands of studies focused on understanding team effectiveness (Kozlowski & Ilgen, 2006). We may not know everything about enhancing the effectiveness of teams but the available evidence suggests that we do know some things. An important feature of teams that makes them somewhat unique with regard to leadership implications is that a team is embedded in a broader system context and task environment, which drives task demands. Another interesting aspect of teams is that their effectiveness is essentially a dynamic process rather than some definitive outcome state. More specifically, “when team processes are aligned with environmentally
driven task demands, the team is effective; when they are not the team is not” (Kozlowski & Ilgen, p. 78). From this perspective team leadership involves a unique team task context and dynamic interpersonal processes of team members. In terms of leadership implications, this suggests that whatever might be done to improve team processes – whether stemming from an individual or multiple individuals – can be construed as team leadership.

There are alternative perspectives of team leadership to consider as well. Salas and colleagues (Salas, Sims, & Burke, 2005) proposed team leadership as one of the five core components of teamwork along with mutual performance monitoring, backup behavior, adaptability, and team orientation. Those authors define team leadership as the ability to direct and coordinate the activities of team members; assess team performance; assign tasks; develop team knowledge, skills, and abilities; motivate team members; plan and organize; and establish a positive climate. This is similar to more recent work on leadership in teams that proposes a functional approach to understanding leadership structures and processes (Morgeson et al., 2010). This functional approach describes 15 team leadership functions that help teams satisfy the critical needs and regulate team member behavior toward goal accomplishment. It is similar in its approach if not content to a previous taxonomy of team performance functions (Fleishman & Zaccaro, 1992). The functional approach to team leadership will be reviewed in more detail in a latter subsection; however, note that it conceptualizes effectiveness (albeit implicitly) in terms of team need satisfaction and goal accomplishment rather than in dynamic process terms (e.g., Kozlowski & Ilgen, 2006).

**Team Performance Cycles**

Team task performance has been viewed through the lens of temporal cycles of goal-directed activity (Marks, Mathieu, & Zaccaro, 2001). This episodic perspective on team tasks distinguishes between *action* and *transition* phases of team performance with the former focusing on task engagement and the latter on task preparation and follow-up reflection. It is
thought that teams are often engaged in multiple tasks that vary in duration with a cycling of action and transition episodes. It is beyond the scope of the present paper to more thoroughly review this episodic approach to team performance, with the exception of the leadership implications that it poses. Specifically, there are certain processes or actions that are targeted at managing the team transition phase (e.g., mission analysis, goal specification, strategy formulation and planning), other actions targeted for the action phase (e.g., monitoring progress, systems monitoring, team monitoring and backup, coordination), and those actions that are relevant for both transition and action phases (e.g., conflict management, motivating and confidence building, affect management). From this perspective it can be seen how team leadership might be conceptualized in contingency leadership terms given that different actions or leadership functions are required in different phases of team performance. Complicating matters is that these team episodes can run sequentially or concurrently in a type of team multitasking, thus making it difficult to link leadership requisites tightly with a given phase of team performance. But one way this might be done more effectively is through identifying different team needs and leadership functions.

Functional Approach to Team Leadership

As noted previously, a functional approach to team leadership conceptualizes a leader as a completer to do or get done whatever is not being handled presently in meeting group needs. This originates from early work conducted by McGrath (1962) for the U.S. Civil Service Commission. McGrath’s approach was very much grounded in behavioral theories of leadership with the overarching goal of outlining requirements for an effective leadership training program. Critical functions of the group according to McGrath include goal-related efforts within what he called the task domain, efforts to maintain the well-being of the group and its interpersonal processes called the interpersonal domain, and efforts to achieve individual goals on the part of group members, which he called individual-need domain. This
an approach was summarized in a 2x2 matrix organized around the type of leadership activity and the orientation of the activity in terms of whether it was provided by sources internal or external to the group.

McGrath (1962) also incorporated a temporal perspective in applying these four critical leadership functions to meeting team needs. Phase 1 involves monitoring activities internal to the group focusing on diagnosing group deficiencies. Phase 2 involves executive action activities also internal to the group that focus on remedial action to correct deficiencies. Phase 3 involving monitoring activities external to the group focus on forecasting environmental changes in their effects. Phase 4 involving executive action activities external to the group focus on preventing environmental changes or their detrimental effects. Although this is a somewhat rudimentary perspective on team leadership, it does highlight that different activities are needed at different points in time, as well as the importance of noting internal versus external orientations with regard to these activities.

Fast forward nearly 50 years, Morgeson et al. (2010) revisited some of the basic tenets outlined by McGrath (1962) in conceptualizing team leadership as the “process of team need satisfaction in the service of enhancing team effectiveness” (p. 8). Consistent with McGrath, the locus of leadership could be internal or external to the team as well as formal or informal in terms of its status. A team leader or project manager is considered to be a formal form of leadership in teams (internal) as would a sponsor, coach, team advisor (external). Shared and emergent forms of leadership are informal (internal) whereas a mentor, champion, or executive coordinators provide informal (external) sources of leadership.

Morgeson et al. (2010) incorporated a different temporal perspective than McGrath (1962) in terms of identifying leadership functions that were most appropriate for transition and action phases (based on the Marks et al., 2001 typology of episodic teamwork). Transition phase leadership functions included composing the team, defining the mission,
establishing expectations and goals, structuring and planning, training and developing the team, sensemaking, and providing feedback. Action phase leadership functions include monitoring the team, managing team boundaries, challenging the team, performing team tasks, solving problems, providing resources, encouraging team self-management, and supporting the social climate of the team.

This provides an accessible taxonomy of team leadership functions in terms of specific behaviors that support these functions and help satisfy team needs. Where this approach is somewhat lacking is in helping leaders identify and diagnose team needs and to be able to adapt behaviors fluidly to fulfill those functions. The approach is also a bit “retro” given that the grounding is in leadership behaviors and the undergirding based on contingency approaches to leadership. Specifically, a leader needs to enact behaviors to fulfill team needs that occur at different temporal phases involving different functions. Leadership contingency theories struggled historically with the many complexities involved with different behavioral sets targeted at different task or environmental contingencies. This approach seems to be no different and perhaps no better when it comes to practical implementation. Another particular challenge with the functional approach to leadership outlined by Morgeson et al. (2010) is that it is highly leader-centric in its focus. Of the four sources of leadership in teams outlined by these authors, three of the sources are thought to emanate from a given individual as opposed to broader collectives. Only shared and emergent forms of leadership address any possible forms of what others have called “leadership in the plural” (Denis, Langley, & Sergi, 2012).

A different approach to functional team leadership was proposed by Burke and colleagues (Burke et al., 2006) stemming from a meta-analysis of 131 effects relating leadership in teams to team performance. Those authors argued that team leaders focus on the primary functional domains of task (e.g., transactional, monitoring, directive leadership) and
developing team members (e.g., transformational, consideration, coaching, empowerment, participative leadership), reminiscent of the distinction between task- and person-focused leadership behaviors proposed by the Ohio State studies (Stogdill & Coons, 1957). Results of the Burke et al. meta-analysis estimated that approximately 12% of the variance in team performance outcomes was associated with task focused leadership whereas approximately 10% of the variance in team performance outcomes was associated with developmentally focused leadership. Task interdependence was also shown to be a significant moderator in that leadership had less of an effect when task interdependence was low rather than when it was high. The results of this research suggests the leadership in teams influences team performance outcomes by shaping the way team members work with core tasks and by attending to the socio-emotional needs of the team. Essentially, these are the same conclusions reached by Ralph Stogdill and the Ohio State researchers only extrapolated to team contexts.

Another approach that might hold promise for more effectively incorporating individual and collective forms of leadership was proposed by researchers at the Center for Creative Leadership (Drath et al., 2008). They argued that the widely accepted leadership ontology consisting of leaders, followers, and shared goals (e.g., Bennis, 2007) is becoming less useful for understanding leadership in contexts such as self-managed teams where there is no formally appointed leader. An alternative ontology is proposed consisting of setting direction, creating alignment, and building commitment among people engaged in shared work. It is argued that anything that brings about direction, alignment, or commitment is a source of leadership. This source could be an individual, a collection of individuals, the task itself, or the external environment. An advantage of this approach is that rather than offering a lengthy list of various leadership functions and behaviors (or competencies) the focus is on just three core leadership tasks of direction, alignment, and commitment. This approach is
intuitively appealing in that it is parsimonious yet elegant in identifying what may be the essence of leadership functions. As such, these core leadership tasks seem to be relevant to teams as well as other leadership contexts. For example, Kozlowski and Ilgen (2006) propose that team effectiveness occurs when team processes are aligned with environmentally driven tasks. The core leadership task of creating alignment is consistent with this dynamic conceptualization of team effectiveness.

**Team Types and Leadership Variants**

This review thus far has treated the team context as if it were completely univocal or homogenous in terms of overarching team purpose and objectives. That is unrealistic given that teams can be used for action and production purposes, to enhance innovation, as well as to undertake basic knowledge creation and discovery. Given differences in overarching goals it is unrealistic to expect the leadership implications to be identical across these various forms of team purposes. This section will identify and elaborate on basic types of teams as well as review selectively the theoretical and empirical leadership literature for each particular type of team. A primary goal is in distinguishing what are science discovery teams from action and innovation teams, their respective leadership implications, and the leadership challenges in the emerging science of multiteam systems.

**Action Teams**

One type of overarching team function is to perform important, interdependent, and highly consequential tasks. At one end of this hypothetical continuum is what some have called extreme action teams, which would include trauma teams, surgical teams, emergency response teams, Special Forces military teams, and the like. At the other end of this hypothetical continuum would be more routine manufacturing or production teams. The latter types of teams are also involved in accomplishing important goals; however, these goals are typically less life-critical than those undertaken by extreme action teams. A question of
relevance for this review concerns the types of leadership either examined empirically or proposed theoretically to assist action and production teams in achieving their goals.

Klein and colleagues (2006) conducted a qualitative study of leadership processes at a trauma resuscitation unit of a major city trauma center in the United States. What makes such teams unusual and considered to be extreme action teams is that they have members who cooperate to perform urgent and highly consequential tasks while simultaneously coping with frequent changes in team composition (Bedwell, Ramsay, & Salas, 2012), and focused on training and developing more novice team members whose services may be required at any time. A focal research question of this qualitative study concerned the development of an understanding of the deep structures and dynamic nature of extreme action team leadership. The primary sources of data in the study consisted of semi-structured, confidential individual interviews as well as observational and archival data pertaining to the trauma resuscitation unit.

The researchers describe the results as revealing a hierarchical, de-individualized system of shared leadership involving dynamic delegation processes. More specifically, this process took the form of more senior leaders’ rapid and repeated delegation of an active leadership role to more junior or novice leaders of the team and then withdrawing this delegation when necessary given the limits of the more junior person’s capabilities. Put differently, senior leaders were engaged in a cyclical process of delegating and then withdrawing the active leadership role, always with the patient’s best interests in mind so that no serious errors in treatment occurred (or at least minimized). Through this dynamic delegation process, the goals of effective treatment of patients and effective development of team members could occur simultaneously.

In a study of team leadership in a less extreme context, Morgeson (2005) adopted a functional leadership approach in examining the external leaders of self-managing production
teams across three organizational contexts (pharmaceutical company, food processing plant, and building and grounds maintenance at a large state university). Interviews and surveys were used to collect data on the nature of events the teams encountered, the actions taken in response to these events, and perceptions of leader effectiveness that were provided by members of the respective team. A key finding from this research is that more active leader intervention activities such as coaching and sensemaking were negatively related to satisfaction with leadership (perhaps because of the perceived intrusion on team autonomy) but were positively related to effectiveness perceptions as events became more disruptive. Thus, the disruptiveness of a team event was found to be an important moderator of the relationship between team leader intervention and perceptions of leader effectiveness. In addition, leader preparation was also shown to be related to perceptions of leadership effectiveness, especially under conditions of high event novelty.

Although these two studies might appear to be quite different in terms of their results, there are points of convergence. Specifically, the leader (either a senior leader or external team leader) periodically intrudes or asserts leadership contingent on features of the task, whether it is observing a potential threat to patient well-being or a novel and disruptive event threatening the performance of a self-managing team. Thus, at various junctures of team performance a formal team leader exerts authority and influence in ways that withdraw fuller participation in leadership or otherwise prevent shared leadership processes from occurring. This is an important message that is reinforced in other studies: It is not a matter of either hierarchical or emergent and shared leadership, but how these processes are used in combination as a task unfolds and threat or novelty are experienced. For example, in a study of new venture top management teams – a type of high-level action team – results suggested that both vertical (i.e., traditional, hierarchical) and shared (emergent, collective) leadership were significant predictors of new venture performance (Ensley et al., 2006). Although this
study did not capture temporal aspects or specific features of the task environment, these findings are consistent with those reviewed in this section that teams adapt to different forms of leadership (vertical and shared) and that they both are important although not necessarily for the same reasons or at the same point in time.

Another approach to understanding team leadership is in focusing on emergent and shared processes within the team. Again it may not be in either/or proposition. In developing a theory of dynamic team leadership, Kozlowski and colleagues (Kozlowski, Watola, Jensen, Kim, & Botero, 2009) elaborated on the role of the formal leader in the team development process in helping the team move from relatively novice to expert status and beyond while building adaptive capabilities in the team. In these latter stages of team development, the team takes on more responsibility for its learning, leadership, and performance. In this manner, vertical and shared leadership operate sequentially with a formal leader helping the team prepare itself to take on the core functions of leadership and learning. Thus, building adaptive capabilities or what others have termed collective leadership capacity (Day, Gronn, & Salas, 2004) is an important team leadership challenge. Additional research is clearly needed – especially longitudinal research – examining how leadership and adaptive capabilities develop over time in teams. It is unfortunate that the vast majority of leadership research is cross-sectional in nature thus providing a relatively static picture of what are more accurately considered to be dynamic processes.

**Innovation Teams**

Another purpose of teams is to introduce and implement new ideas, processes, or procedures. These kinds of teams can be termed innovation teams, which serve somewhat as a conceptual bridge between action teams oriented toward getting work done under sometimes extreme conditions to science teams that are engaged in more basic discovery and knowledge creation. An example of an innovation team might be one that is engaged in
research and development (R&D) functions. A question of relevance for this paper is what are the implications for innovation teams and how might they differ from the leadership implications in other kinds of teams. Evidence in the form of empirical research and theory will be reviewed with that aim.

A review of the empirical literature on leadership in R&D organizations (Elkins & Keller, 2003) suggested that transformational project leaders who communicate an inspirational vision and provide intellectual stimulation are associated with a higher likelihood of project success. In addition, those project leaders who develop a high quality leader-member exchange (LMX) with project members tended to be associated with successful projects. Boundary spanning activity and championing by the leader are also important factors for project success. A repeated theme in this literature revolves around the issues of transformational leadership and LMX quality.

Research on the topic of champions of technological innovation compared matched pairs of champions and non-champions of innovation, demonstrated that the former reported using transformational leader behaviors to a significantly greater extent than the latter (Howell and Higgins, 1990). Champions also exhibited higher risk-taking behaviors, initiated more influence attempts, and used a greater variety of influence tactics the non-champions. In this study, a champion was described as an individual who informally emerges and makes a meaningful contribution to the innovation by actively and enthusiastically promoting its progress through critical stages. This type of individual fits within the Morgeson et al. (2010) typology of an external and informal leadership source for a team.

Edmonson and colleagues (Edmondson, Bohmer, & Pisano, 2001) conducted research on 16 hospitals that implemented new, minimally invasive cardiac surgery technologies. Successful implementation involved an active enrollment process by which new team members were motivated to join by leaders and then subsequently engaged in practice
sessions. In particular, leaders (i.e., surgeons) who promoted an emergent state of team psychological safety (i.e., a team climate in which well-intentioned interpersonal risks were not punished and even encouraged) was found to be important in shaping more effective team learning processes and ultimately the successful implementation of new technology (see Edmondson, 1999 for similar results of the role of leaders in shaping psychological safety in manufacturing teams). Although not framed explicitly in these terms, those leaders promoting psychological safety were acting in a manner highly consistent with transformational leadership (especially individualized consideration) in terms of also putting the team’s performance and well-being ahead of their own personal agendas.

In a study of 118 R&D project teams across a five-year time span, transformational leadership, initiating structure, and selected substitutes for leadership were examined as longitudinal predictors of various aspects of team performance (Keller, 2006). Transformational leadership was found to predict technical quality, schedule performance, and cost performance following a one-year time lag. Transformational leadership also predicted profitability and speed to market five years later. Initiating structure predicted all performance measures, whereas the substitutes for leadership factors of subordinate ability and an intrinsically satisfying task predicted technical quality and profitability. Subordinate ability also predicted speed to market. Another interesting finding from this research is that transformational leadership was found to be more important for research projects than for development projects, whereas initiating structure was more effective in development projects. The implications of these results suggest that leadership is a complex, multidimensional process and that no one best way of leading will be best suited across project teams or relevant for all types of team outcomes.

A recent study using a field sample of 101 virtual R&D teams (Hoch & Kozlowski, in press) examined the effects of traditional hierarchical leadership (i.e., transformational
leadership, LMX, career mentoring), structural supports or what might be considered leadership substitutes (i.e., reward systems, communication and information), and shared team leadership (i.e., cognitive team learning, perceived team support, member–member exchange) on leader-rated team performance in terms of work quantity, quality, keeping within project schedule, and keeping within budget. Consistent with previous findings, hierarchical and shared leadership were both significantly related to team performance; however, teams that were more virtual demonstrated attenuated relations between hierarchical leadership and team performance but stronger effects for structural supports. The implications of these results are that both hierarchical and shared leadership may be important for R&D teams in virtual environments, but shared leadership and structural supports (i.e., substitutes for leadership) appear to be more important factors as team virtuality increases.

A multilevel model of moderators of innovative performance teams was recently developed and tested using 95 R&D teams across 33 Chinese companies (Chen et al., in press). Transformational leadership was found to predict the team motivational state of support for innovation climate which in turn predicted team innovative performance. The multilevel nature of this model demonstrated cross-level effects for team motivational states on individual member motivation as well as directly and indirectly predicting individual innovative performance. Others have noted that teams are embedded in a multilevel system that involves individual, team, and organizational aspects (Kozlowski & Ilgen, 2006); thus, examining the multilevel and cross-level influences on motivation at the team and individual level is commendable. Furthermore, it demonstrates the importance of transformational leadership in shaping team motivational emergent states that mediate the relationship between leadership and individual motivation, individual innovative performance, and team innovative performance.
Another multilevel approach to understanding the influences of leadership on innovative performance examined the effects of team-member exchange (TMX) on individual commitment the intention to share knowledge and team performance (Liu, Keller, & Shih, 2011). TMX is defined as an individual’s perception of exchange relationships with coworkers in the work group (Seers, 1989). The results from 301 participants representing membership in 52 R&D project teams all from different companies suggested that work unit TMX increases intention to share knowledge through increasing group members’ team commitment. At the team level, the results support the relationships between team knowledge sharing and team performance. An interesting moderator of these effects was found for TMX differentiation in terms of moderating the relationship between work unit TMX and team performance. In other words, if there was a great deal of differentiation in TMX quality within the team there was evidence of lower performance even if the average TMX was relatively high. Performance in this study was measured by team leader responses to a four-item measure including items such as “the team members are successfully managing project related challenges or obstacles as they occurred.”

A very different kind of study using a multiple case, inductive approach to examining eight technology collaborations between 10 organizations from 2001-2006 (Davis & Eisenhardt, 2011) addressed the more macro question of why some interorganizational relationships produce technical innovations while others do not. An interesting finding from this qualitative research showed that the leadership processes of the collaborations varied widely. Some partners used a dominating leadership type of style in which a single partner controlled decision-making, determined innovation objectives, and mobilized participants. Other partners used a consensus leadership process in which they shared decision-making, agreed to common objectives, and mobilized partners together. But unexpectedly, those partners who used a rotating leadership process of alternating decision control, “zig-zagging
objectives” to develop deep and broad innovation search trajectories, and fluctuating network cascades to mobilize diverse participants over time were associated with better innovation performance than the other forms of leadership that were adopted. The authors interpreted these results as suggesting the process components of rotating leadership enhancing a recombination mechanism leading to new and useful technology combinations.

Science Discovery Teams

The type of team purpose of focal interest to this paper concerns teams that are involved in basic knowledge creation. The term science discovery team reflects that these are science teams whose primary objectives involve discovery and dissemination of knowledge mainly in the form of scientific publications and patents. The term science discovery is used to differentiate these kinds of teams from those engaged in other forms of research as part of an R&D function. Science discovery teams are often multidisciplinary involving complementary contributions among members of multiple disciplines or interdisciplinary involving the systematic integration of ideas requiring the development of new approaches to understanding (Fiore, 2008). There is a trend toward teams that are transdisciplinary in terms of cutting across disciplines with the objective of integrating and synthesizing content theory and methodology from any disciplinary area that can help shed light on a given research question (Hall et al., 2012; Morgan et al., 2003; Stokols et al., 2003). Members of science discovery teams typically work face-to-face, sharing work space, materials, technologies, objectives, hypotheses, and even to some degree, shared professional reputation and fate (Hackett, 2005). A basic challenge associated with leading science discovery teams is that they often involve working across disciplines and integrating ideas from various scientific perspectives, some of which the team leader may be relatively unfamiliar with.

It has been argued that this type of interdisciplinary or transdisciplinary approach is inherently team-based research (Fiore, 2008). Others have positioned this type of team-based
scientific research within a multilevel systems perspective based in the “science of team science” or SciTS (Börner et al., 2010). This is an emerging research discipline in which the processes by which science discovery teams organize, communicate, and conduct research are studied. Related to differences in the objectives or mission of science discovery teams, they also appear to involve different kinds of leadership challenges than those related to action or innovation teams. For example, Gray (2008) proposed that transdisciplinary teams require leadership that creates a shared mental model or mindset among team members (i.e., cognitive tasks), attending to basic structural needs of the team in terms of managing networks that develop among teams of teams (i.e., structural tasks), and also focusing on developing effective process dynamics within and between teams (i.e., processual tasks). Gray frames the leadership needs of transdisciplinary teams in terms of collaborative leadership.

Collaborative leadership as Gray (2008) presents it is conceptually very similar to shared leadership (Pearce & Conger, 2003). It may be tempting therefore to conclude that effective leadership in interdisciplinary and transdisciplinary teams might be best accomplished by facilitating collaborative and shared leadership processes; however, this may be both premature and overly simplistic. Although based on traditional molecular science laboratories engaged in unidisciplinary science (i.e., one PA leading a team of junior scientists and students), a qualitative study examining the tensions and paradoxes that arise during the life course of research groups found that there was no one best way to lead (Hackett, 2005). What scientists appear to have in common with business leaders is a varied sense of what it takes to lead effectively – what those in the leadership field have called implicit leadership theories (Epitropaki & Martin, 2004; Offermann, Kennedy, & Wirtz, 1994). Through his qualitative interviews, Hackett found some science leaders who adopt permissive, participative leadership styles perhaps “because it honors the traditional
principles of independence in science” (p. 800). But there are other science leaders who are more forceful in their direction and follow more sharply drawn lines of inquiry. Hackett interviewed one senior science leader who said: “I don’t have a problem with being autocratic… I’m in charge of this lab. It has to be that way in science. You cannot do science in a democratic way, because it has to be one way of thinking” (p. 801). An empirical question for future research is whether this kind of leadership perspective would work effectively in a transdisciplinary science context.

This apparent leadership paradox is consistent with the theme emerging from the present review of team leadership: From what we know from the available evidence is that there is no one best way to lead in terms of enhancing team effectiveness. From a science leader development perspective what may be required is helping to develop mindsets and competencies that allow leaders to enact directive as well as more participative, collaborative, or shared forms of leadership depending on team needs. As noted by Hackett (2005), an inherent tension in science teams is between directing the research of a lab (or labs) and allowing autonomy and democratic participation. This would appear to also be the case in transdisciplinary science settings. For example, if an important leadership function is identifying important scientific problems and channeling the team’s efforts toward solving them (Fruton, 1990, as cited in Hackett, 2005) then there are different ways of addressing these core leadership functions. Revisiting the leadership ontology of direction, alignment, and commitment (Drath et al., 2008), these core leadership tasks are embedded in what Fruton argues are core leadership requirements in science discovery teams. Note that direction, alignment, and commitment can come from an individual such as the formal team leader or from more collective and collaborative (i.e., shared) leadership processes.

Transdisciplinary science inherently involves collaboration among scholars from two or more scientific disciplines in which the products of the collaboration reflect an integration
of conceptual and methodological perspectives (Stokols et al., 2003). Effective collaboration is a key to successful transdisciplinary science and collaboration provides a foundation for shared leadership. The latter is typically more of an informal process that develops along with collaboration rather than through formal appointment. Thus, anything that potentially undermines or prevents effective collaboration is also an obstacle to the development of shared leadership. As a result, the default might be to revert to more hierarchical and autocratic leadership forms, which might make it more difficult to foster collaboration.

Stokols et al. (2003) discuss a number of obstacles to effective transdisciplinary science collaboration based on their evaluation research. Some of the more common issues noted by the authors were university inexperience with transdisciplinary centers, lack of opportunities for face-to-face interaction among researchers, tenure and merit review procedures that reward individual or unidisciplinary research, disciplinary tribalism that disparages research from alternative perspectives, a low level of readiness to collaborate, among other factors.

It is important to recognize that vertical and shared leadership can be used to address different aspects of the taskwork associated with transdisciplinary science. Stokols et al. (2013) found that the antecedent conditions for successful transdisciplinary science centers included opportunities to engage in face-to-face communication, a strong commitment to collaborative values and behaviors, along with the type of institutional structural supports (e.g., allocation of shared research space) that facilitate cooperation and engagement in successful transdisciplinary science. These are the kinds of things that a formal (vertical) leader can help to foster through the exercise of formal administrative influence and appropriate forms of modeling. There is a robust literature on the effectiveness of social modeling on the behavior of others (Bandura, 1986) and especially the modeling effects of
powerful others such as formal leaders. In this way, aspects of vertical leadership can help to shape the norms for collaboration and respect for different disciplinary perspectives.

As an example, cross-disciplinary tensions and language constraints experienced by members of the UC Irvine and Brown University Transdisciplinary Tobacco Use Research Centers (TTRUC), respectively, resulted in a series of off-campus retreats (Stokols et al., 2003). One outcome of these retreats was greater tolerance and understanding of different disciplinary perspectives as a basis for future collaboration. Although details of how these meetings were organized and conducted were not detailed by the authors of the evaluation report, it seems likely that a formal leader (or leaders) of the respective initiatives saw the need for building greater trust and understanding among members of the Center. Having the foresight and influence to pull people together with the goals of improving communication and facilitating sustained collaboration is a prime example of how vertical leadership can be used in the name of fostering greater shared leadership.

In terms of what shared leadership might look like in transdisciplinary science teams, one view is that all team members (regardless of formal position) are open to being influenced and to influence others. This is the kind of simultaneous shared leadership that can foster greater overall shared leadership capacity in a team (Day et al., 2004). This type of mutual influence process was likely behind the Brown TTURC initiative that resulted in the development of a shared transdisciplinary health economic model to assess the costs of smoking (Stokols et al., 2003). Other examples are also provided as to how different TTRUC teams collaborated to build a shared database that increased the overall sample size and allowed the teams to analyze their data in novel ways. In this initiative what started as a single-team project evolved into a multiteam system (i.e., a team of teams), which face similar leadership challenges with regard to enhancing cooperation across team and
disciplinary boundaries. Additional insight on multiteam systems will be provided in a subsequent section of this paper.

Existing empirical research on science discovery teams is relatively meager, especially research that links to good measures of research group productivity. Research on leadership in science discovery teams is virtually nonexistent. There is some recent research that has leadership implications for science teams; however, such implications need to be followed with empirical testing before any firm conclusions can be drawn. One such study examined research group heterogeneity and its relationships with team productivity measured five to nine years later (Cummings, Kiesler, Zadeh, & Balakrishnan, in press). Publication and citation data were examined for 549 research groups that varied in disciplinary heterogeneity, institutional heterogeneity, and size. Larger groups tended to be more productive than smaller groups – perhaps due to more intellectual capabilities available in larger groups (Wuchty, Jones, & Uzzi, 2007) – but productivity declined as heterogeneity increased either in terms of having more disciplines or more institutions to align. The authors suggested that the advantages of heterogeneity (i.e., diversity) may be better leveraged in smaller and more cohesive units, implicitly suggesting that smaller science discovery teams might be preferable. Another perspective on these findings suggests a particular leadership challenge associated with a need for boundary spanning activities.

The diversity literature has examined so-called faultlines that develop in heterogeneous groups as a function of self-categorization processes, social identification, and similarity attraction (Lau & Murnighan, 1998, 2005; Thatcher & Patel, 2012). Faultlines are defined as hypothetical dividing lines that split a group into two or more subgroups based on the alignment of one or more individual attributes (e.g., function or discipline). Faultlines have been found to influence group processes (e.g., conflict, cohesion), affective outcomes (e.g., satisfaction), and group decision-making and performance (Thatcher & Patel, p. 970).
Another way to conceptualize faultlines is as boundaries that develop within and between teams that detract from their overall effectiveness. These kinds of boundaries can span levels (i.e., vertical boundaries); functions, teams, peers, or expertise (i.e., horizontal boundaries); various stakeholder interests; geography; or demography (Ernst & Chrobot-Mason, 2011). Thus a relevant question to consider is what boundary spanning leadership might entail and how it could be particularly relevant for transdisciplinary science teams.

Based on survey and interview-based research, Ernst and Chrobot-Mason (2011) inductively derived six boundary spanning leadership practices organized around three overarching processes. The first of these processes is Managing Boundaries in which the leadership practices of buffering (defining boundaries to create safety) and reflecting (creating understanding of boundaries to foster respect) are recommended. The second overarching process of Forging Common Ground consists of the leadership practices of connecting (suspending boundaries to build intergroup trust), and mobilizing (reframing boundaries to develop broader community). The third overarching process is Discovering New Frontiers, which involves the leadership practices of weaving (interlace boundaries to advance intergroup interdependence) and transforming (cross-cut boundaries to enable and facilitate intergroup reinvention). Each of these various leadership practices can take different forms depending on the type of boundary that needs to be spanned (i.e., vertical, horizontal, stakeholder, demographic, geographic).

Although interesting and very practically oriented, it is important to note that boundary spanning leadership as conceptualized by Ernst and Chrobot-Mason (2011) has not been tested or otherwise empirically evaluated with regard to promoting effective team outcomes. It is also the case that boundary spanning leadership is not designed specifically for science discovery or any other particular type of team. Nonetheless, if SciTS and transdisciplinary teams are the new normal in science (Börner, et al., 2010; Fiore, 2008; Hall
et al., 2012; Morgan et al., 2003) – in addition to the emergence of multi-university teams as the fastest growing type of authorship structure in science (Jones, Wuchty, & Uzzi, 2008) – it makes good sense to focus on potential faultlines and relevant boundaries that might impede effective coordination, collaboration, and contribution. In further discussion of this boundary-spanning approach, the next section will address the nascent field of multiteam systems on the leadership challenges associated with such systems.

**Multiteam Systems**

A relatively recent development in the team literature is in addressing multiteam systems, or teams of teams. Another way of thinking about multiteam systems is as complex systems of teams used to accomplish ambitious goals too large for any single team (Zaccaro & DeChurch, 2012). As such, multiteam systems could consist of action, innovation, science or discovery teams, or possibly a combination of different team types. The origins of interest in multiteam systems can be traced to military contexts and especially challenges with successfully engaging in joint operations missions. In other words, the original focus was on extreme action teams; however, multi-team systems also appear highly relevant for science discovery endeavors.

Zaccaro and DeChurch (2012) articulated different structures of leadership including three forms of shared leadership – rotated, distributed, and simultaneous or emergent – that can develop in different types of multiteam systems. It should also be noted that leadership in multiteam systems can occur through either vertical or shared forms depending on various systems characteristics. An overview and brief description of the various forms of leadership in multi-team systems is presented in Table 1.
Table 1: Forms of Leadership in Multiteam Systems

<table>
<thead>
<tr>
<th>Leadership Form</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical: Fully Centralized</td>
<td>Leadership responsibilities, decisions, and actions are conducted by single individual in a formal leader role.</td>
</tr>
<tr>
<td>Vertical: Multilevel</td>
<td>Leadership is organized formally in a multitier structure in which lower level leaders are subordinated to higher-level leaders.</td>
</tr>
<tr>
<td>Shared: Rotated</td>
<td>Full responsibilities of leadership functions are cycled among different individual members of the multiteam system.</td>
</tr>
<tr>
<td>Shared: Distributed</td>
<td>Different component team leaders, or members of the leadership team, are individually responsible for separate leadership functions.</td>
</tr>
<tr>
<td>Shared: Simultaneous</td>
<td>All component team leaders, or members of the leadership team, are mutually engage in leadership activities throughout phases of the multiteam performance cycle.</td>
</tr>
</tbody>
</table>

Note. Adapted from Zaccaro and DeChurch (2012).

Zaccaro and DeChurch (2012) further develop a functional approach to multiteam systems, proposing leadership functions within teams, between teams, and external to teams organized under transition and action processes of teams discussed previously (Marks et al., 2001). In addition to the functional leadership approach that is taken, another familiar feature of the leadership forms proposed by these authors is that they include both the traditional, vertical types of leadership as well as various forms of shared leadership. This again suggests that may be no one best leadership form even in multiteam systems. Leaders need to be versed in leading teams through various forms and structures. Some of the team compositional factors thought to be important in motivating different forms of multiteam leadership include the overall size of the multiteam system, the amount and kind of diversity, and geographic dispersion. Factors related to task and goal characteristics connecting
component teams to one another with leadership implications include the level of
interdependence among component teams as well as the respective power distribution among
teams. In addition, more mature multiteam systems were proposed to display greater levels of
shared leadership than less mature multiteam systems, which makes sense given that shared
leadership takes time to develop (DeRue, 2011).

There are many potential challenges associated with leading across multiple teams,
and building effective collaborations is at or near the top of the list. A practical way to
attempt to deal with the complexities of teams and teamwork is through having members
collectively develop a team charter, which provides a written agreement for task
accomplishment and teamwork (Mathieu & Rapp, 2009). Others have suggested that such
charters can be used in multiteam settings (i.e., multiteam charters) to develop effective
norms for between-team communication and leadership processes. Asencio, Carter,
DeChurch, Zaccaro, and Fiore (2012) illustrate how multiteam charters can help to develop
shared leadership structures and communication networks that are efficient and help to align
all members of the system. Multiteam charters guide participants in identifying a
representative from each team to participate in system-level leadership, help coordinate
multiteam actions, and convey information across team boundaries. This makes practical
sense in terms of providing a deliberate process to set team and multiteam expectations and
manage the development of effective norms; however, there is an explicit assumption that
shared leadership processes are inherently needed and would result in the most effective
outcomes. These assumptions need to be tested empirically before any firm conclusions can
be reached regarding multiteam charters as well as the prescribed shared leadership
processes.

To date there has been relatively little empirical research on leadership in multiteam
systems. One example involved historiometric analyses of leadership in mission critical
multiteam environments (DeChurch et al., 2011). The goal of the research was to evaluate critical incidents and from them inductively derive a set of leader functions essential for orchestrating effort in mission critical multiteam contexts. The primary functions induced from the cases that were analyzed included *strategy* (i.e., leader analysis of the multiteam system performance environment, structuring the work, prioritization of tasks, planning and goal setting) and *coordinating* (leader facilitation of work processes during task engagement). Such functions were further delineated with regard to within, between, and across various teams in the multiteam system. Given the focus on extreme action teams in critical multiteam environments, it is unclear to what extent these results might generalize to science discovery team environments but it is a methodology worth considering in future research.

In a laboratory study examining leadership functions hypothesized to be important in synchronizing multiteam systems, DeChurch and Marks (2006) manipulated leader strategizing and coordinating in assessing their effects on functional leadership, inter-team coordination, and the performance of the multiteam system. Results supported a multilevel (i.e., team and multiteam) model in which leader training positively influenced functional leadership, which in turn improved inter-team coordination, and ultimately resulted in improved performance of the multiteam system. The study participants were undergraduate students involved in an air combat effectiveness simulation so the generalizability of these findings to science discovery teams needs further study. Unfortunately, science discovery teams do not readily lend themselves for laboratory simulation. But as SciTS increasingly involves transdisciplinary research engaged through multiteam systems researchers will need to give greater attention to complex systems of teams instead of focusing solely on intrateam processes and outcomes.
Summary and Conclusions

This review examined the available evidence regarding the science of team leadership, including a look to changes in leadership theory and research over time, an overview of team science and the implications for science team leadership, and the basic types of teams (i.e., action, innovation, and science discovery), and their respective leadership challenges. Team leadership is an emerging area of research that is growing quickly. Even though most leadership research still has only indirect implications for team effectiveness (Kozlowski and Ilgen, 2006) that gap is closing. Whereas team leadership has developed under the broad category of contextual leadership approaches, it is gaining status in its own right.

Although not completely coherent in its organization or message, there is a foundation of theory and research from organizational psychology and organizational behavior with regard to team leadership that does not appear to be widely considered by many outside of the field. Part of this issue may be due to the historical silos that exist between scientific disciplines. A related issue concerns how little research has been done on science teams as compared with action or innovation teams, along with potential differences in the leadership challenges faced by the respective team types. This may also be due to certain historical factors in that organizational psychology has tended to focus more on action and innovation teams given their military and business relevance, respectively, in its examination of teams and teamwork. Clearly, there is a need for research on science discovery types of teams to advance an evidence-based understanding of what helps them work effectively and the kinds of leadership factors that can help to enhance the likelihood of team success in scientific endeavors.

An interesting conclusion to emerge from this review is that the foundation of team leadership appears to be in areas that otherwise are not receiving a great deal of research
attention. Specifically, functional team leadership approaches (e.g., Morgeson et al., 2010) appear to be based heavily on leader behavior theories. In addition, linking leadership functions to team cycles or episodes (i.e., transition, action) is very much a contingency leadership approach. But neither behavioral approaches nor contingency theories of leadership have been actively researched in recent years (Day and Antonakis, 2012). It is unclear exactly what the potential implications are of basing team leadership on these somewhat outdated leadership approaches. Contingency theories of leadership in particular collapsed due to their own intricacies and complexities with trying to link various leader behaviors with different environmental factors. There is a real risk of the team leadership literature following suit given its current grounding in behavioral and contingency approaches to leadership.

An alternative perspective comes from the work proposing a new ontology of leadership based on the fundamental leadership tasks of direction, alignment, and commitment (Drath et al, 2008). Put simply, anyone or anything that brings about these core tasks is as a source of leadership. This is a flexible ontology in that it includes not only the potential role of an individual leader but more collective approaches to leadership such as those found with shared leadership theory. This pertains to another conclusion emerging from this review in that it appears there is no one best way to lead teams. There is evidence to suggest that more traditional or vertical approaches to leadership in conjunction with more collective or shared leadership processes are associated with higher levels of effectiveness than either of these leadership approaches alone. The evidence is not entirely consistent with this approach (e.g., Davis & Eisenhardt, 2011; Hoch & Kozlowski, in press) but the majority of the published research suggests that “and/both” leadership approaches (vertical and shared leadership) may heighten team effectiveness as compared to either vertical or shared
leadership approaches alone. A question that requires empirical scrutiny is whether this finding from the leadership literature also pertains to transdisciplinary science teams.

The current evidence around leadership in science discovery teams is very thin and mainly qualitative in nature. Recent research with important potential leadership implications (but not directly examining leadership processes) in science discovery teams has shown that group heterogeneity can cause problems in such teams especially as team size increases (Cummings et al., in press). This suggests that an important leadership challenge for leaders of science discovery teams is in managing the potential faultlines or boundaries that can develop within and between teams. There is not a great deal in the literature around boundary spanning leadership, with the exception of more practitioner-oriented offerings (e.g., Ernst & Chrobot-Mason, 2011). This suggests that there should be research attention given to how leaders manage and exploit boundaries in science discovery teams, especially given the prominence of multi-university research teams in science (Jones et al., 2008).

Finally, there is emerging interest in multiteam systems that have direct implications for leadership in science discovery contexts. It is fairly common for scientific investigators to manage multiple teams of laboratory researchers. It also seems to be the case that as “big science” problems are pursued, they will require teams of scientists coordinating and collaborating around goals such as finding the causes and cures of major health problems facing humankind. Complex scientific problems are probably too big for any single team to successfully tackle. Thus, multiteam systems will likely become more prevalent than single team approaches in transdisciplinary science. Clearly, there are leadership implications in multiteam systems that need to be examined particularly around the issues of boundaries and faultlines. But what is essential is that researchers expand the lens around the science of team science (i.e., SciTS; Börner, et al., 2010) to take a broader systems perspective regarding science discovery teams and their leadership implications.
Research and Practical Recommendations

The final section of this review sets forth a few research as well as practical recommendations with regard to advancing the science of team leadership and team leadership development. A question of interest is where are the research gaps in the areas of team science leadership and its development. Unfortunately, there is little programmatic research on science discovery teams, even less when it comes to understanding the leadership challenges associated with leading science discovery teams, and virtually nothing with regard to the developmental imperatives for science leaders. Thus, it is pretty much an unexplored “blue sky” space. Research of all kinds is needed to understand the various forms of effective science team leadership and how to develop it. Nonetheless, there are particular areas that might provide useful inroads to a better understanding of the core issues.

One specific area worth considering in terms of research is the role of transformational leadership. This is an active field of research, although it has its critics (van Knippenberg & Sitkin, 2013). Why transformational leadership? One reason is the interesting finding reported by Keller (2006) showing that in R&D teams transformational leadership was more important for promoting relevant team outcomes in research projects than for development projects. Nonetheless, it is unclear from the write-up how similar these research teams are to more basic science discovery teams. It is also a research finding that has yet to be replicated. Despite these gaps, the role of transformational leadership in science discovery teams is a topic that is worth examining.

As noted by Kozlowski and Ilgen (2006), there is at least 50 years of research devoted to topics related to teams and teamwork. This provides a robust foundation of evidence on which to guide research and practice in the science of team science or SciTS (Börner, et al., 2010). It may be the case that scientists outside of the field of organizational psychology have little idea about the breadth and depth of this evidence-based foundation. It may be just as
likely that those in the field of organizational psychology and organizational behavior who are engaged in team-based research have little idea of the unique challenges associated with science discovery teams. Related to this issue is a need to clearly differentiate the leadership challenges experienced respectively in action teams, innovation (R&D) teams, and more basic science discovery teams. In particular, the potentially important role of boundaries and faultlines in science discovery teams is something highlighted in this paper. But more systematic research is needed to more fully delineate the differences in leadership challenges across these various team types.

In terms of key research questions, the present review and existing literature suggests the following:

1. Are science discovery teams with transformational leaders as PIs or Center Directors more effective than those led by non-transformational leaders? The evidence from R&D (i.e., innovation) teams suggests that could be the case (e.g., Chen et al., in press; Elkins & Keller, 2003; Keller, 2006); however, the effects of transformational leadership in science discovery teams—especially those engaged in transdisciplinary science—has not been studied.

2. Does the development of shared leadership in a science discovery team result in better outcomes (e.g., more publications, greater innovation, higher citation counts) as compared with teams using mainly traditional hierarchical (i.e., vertical) leadership? Do science teams that have the capacity for both kinds of leadership processes perform best of all? There appears to be a need for greater collaboration and mutual influence processes in transdisciplinary teams in particular, which would suggest a need for shared forms of leadership; however, this remains an empirical question.

3. What is the role of formal science leaders in helping to facilitate or otherwise develop collaborative working norms and shared leadership in their teams? Research from
other domains such as surgical teams has demonstrated the importance of the formal leader (i.e., surgeon) in the development of shared leadership and its importance for successfully adopting new surgical innovations (Edmondson et al., 2001). Put somewhat differently, do the types of collaborative norms and shared leadership structures emerge in a bottom-up manner emanating from team members or is it nurtured in more of a top-down manner emanating from senior leaders on the team?

Regarding practical recommendations, one area to focus is on emphasizing and disseminating what we know regarding the science of team science among research leaders. One such area is on developing understandings of different ways to lead among research scientists. Examining the various leadership forms in multiteam systems proposed by Zaccaro and DeChurch (2012) shows that there are at least two different ways of leading in more traditional or vertical forms (i.e. fully centralized, multilevel) as well as three different forms of shared leadership (i.e., rotated, distributed, simultaneous) (see Table 1). If thinking is for doing – as at least one prominent research psychologist suggests (Fiske, 1992) – then being able to envision different forms of team leadership is the first step to being able to enact different ways of leading.

A focal question concerns how to best develop the mindsets and competencies needed to lead science discovery teams. There is a multi-billion dollar industry devoted to leadership development initiatives, which suggests that there is no “quick fix” type of answer as to how to develop better science team leaders. Making resources available such as field guides devoted to topics such as collaboration and team science is a start (e.g., Bennett, Gadlin, & Levine-Finley, 2010). But the issue is not one of simply providing leadership training (applying proven solutions to known problems) but how to best engage in ongoing leadership development. The latter requires a much more long-term perspective that is potentially based on thousands of hours – perhaps a decade or more – of dedicated practice (Day, 2010;
Ericsson, Krampe, & Tesch-Römer, 1993). This is something that needs to occur in the context of ongoing science work and not just as a function of seminars, workshops, and reading field guides. Leader identity may play an important role in this process.

It is been argued that internalizing a leader identity provides the motivation for practice over extended periods of time needed to develop an expert leader (Day, Harrison, & Halpin, 2009). Although mainly speculative at this point, it seems likely that scientists engaged in interdisciplinary and transdisciplinary research tend think of themselves (i.e., identify) primarily in terms of researchers and scientists rather than research leaders or science leaders. If little consideration is given to being a leader on the part of a science team leader then it is unlikely that the available evidence around team leadership will be sought out, examined, or used to guide actions with regard to leadership. It is also unlikely that there will be investments made in pursuing leader development opportunities. Identity motivates and guides practice (among other things), so developing a leader identity should be part of becoming a capable and effective team science leader.

An open question concerns how to foster leader identity among science leaders. Given the lack of attention given to leadership issues in the literature on the science of team science, the first step would seem to be to increase awareness of the need to develop leadership skills and competencies for engaging effectively in transdisciplinary science. The underlying message is that even if you cannot be the leader, everyone needs to be prepared to be a leader to maximize collaboration and the performance of the team. Although researchers have developed a competency model in training transdisciplinary scientists that also addresses potential methods for developing these competencies (Nash et al., 2003), there should be efforts devoted to developing a SciTS leadership competency model. Doing so and disseminating it widely may help to motivate scientists to also begin thinking in terms of being a leader (i.e., adopting a leader identity).
Related to developing a leader identity, Nash et al. (2003) note that the Yale University TTURC offers bimonthly seminars with the purpose of bringing scientists from different schools and departments together with doctoral students, post-doctoral fellows, and others to cover myriad topics relevant to science and scientists. This type of regular multi- and transdisciplinary engagement could also offer opportunities for creating dialogue around science leadership. Increasing awareness about the science of team science as well as the science of team leadership might provide an engaging introduction to relevant issues, including the importance of fostering a science leader identity. This would represent a beginning and not the end of what is needed to develop high-performing science team leaders.

The evidence is clear that teams have become a dominant force in knowledge creation both in terms of the quantity as well as quality of research that is produced (Hall et al., 2012; Wuchty, Jones, & Uzzi, 2007). Research also suggests that as science teams become larger and more heterogeneous the associated leadership challenges increase (Cummings, et al., in press). For these and other reasons it is critical that more research attention is given to issues relating to team science leadership. We know quite a bit about leadership and a lot about teams but these bits need to be better connected and integrated within the context of transdisciplinary science. The good news is that what we know about leadership and teams can help provide a sound foundation on which to go forward both in terms of research as well as practice in shaping the field of leadership in science discovery teams.
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