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Published in final edited form as:
J Investig Med. 2012 June ; 60(5): 768–775. doi:10.231/JIM.0b013e318250871d.

Collaboration and Team Science: From Theory to Practice

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Abstract

Interdisciplinary efforts are becoming more critical for scientific discovery and translational research efforts. Highly integrated and interactive research teams share a number of features that contribute to their success in developing and sustaining their efforts over time. Through analysis of in-depth interviews with members of highly successful research teams and others that did not meet their goals or ended due to conflicts, we identified key elements that appear critical for team success and effectiveness. There is no debate that the scientific goal sits at the center of the collaborative effort. However, supporting features need to be in place to avoid the derailment of the team. Among the most important of these is trust: without trust the team dynamic runs the risk of deteriorating over time. Other critical factors of which both leaders and participants need to be aware include developing a shared vision, strategically identifying team members and purposefully building the team, promoting disagreement while containing conflict, and setting clear expectations for sharing credit and authorship. Self-awareness and strong communication skills contribute greatly to effective leadership and management strategies of scientific teams. While all successful teams share the characteristic of effectively carrying out these activities, there is no single formula for execution with every leader exemplifying different strengths and weaknesses. Successful scientific collaborations have strong leaders who are self -aware and are mindful of the many elements critical for supporting the science at the center of the effort.

Keywords

collaboration; trust; translational research; managing conflict while promoting disagreement; sharing credit

Introduction

Scientific collaboration is more strikingly prevalent today than it was decades ago (1). In many areas of biomedical science the trend is toward catalyzing collaborative efforts that bring together researchers with diverse scientific backgrounds and perspectives to address perplexing questions and solve complex problems that benefit from an interdisciplinary or multidisciplinary approach (2).

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A Paper from:
Career Development Workshop: Productive Translational Research: Tools for Connecting Research Cultures and Managing Conflict.

We describe collaboration and team science along a continuum extending from collaborations with minimal levels of interaction to scientific teams with significant levels of interaction and integration (Fig 1). To illustrate, on the low interaction end of the spectrum an independent investigator's laboratory may have limited interaction with other labs, yet within the laboratory, the lab members may collaborate to achieve a particular set of objectives. An intermediate level of interaction could be characterized by a more multidisciplinary approach where two or more researchers from different labs work on a project together, yet are not highly integrated. In this scenario each might bring his or her specific expertise and skills to a project by performing experiments and analyzing data with a common or related set of samples and then put the results together to tell a scientific story. Those participating in this effort may or may not continue interacting when the work is completed.

When we talk about a highly integrated and interactive collaborative team, which is the focus of this paper, we are referring to a group that is led by one or more scientists and is composed of researchers with diverse backgrounds and different areas of expertise. The collaborators will have developed common objectives, coordinated their resources, and composed a shared agenda of activities directed toward achieving those objectives. Typically, such collaborations are identifiable by a number of characteristics that reveal the ability of the group to achieve a high level of integration and interaction: meeting regularly, physically or virtually; defining a vision and setting goals shaped by a powerful scientific idea; communicating effectively; and encouraging intellectual disagreement. Frequently the group has a high level of trust and members openly share both data and credit for the research accomplishments. Such teams have a principal leader or co-leaders and it is often the case that additional leaders emerge from the formed team to take on new aspects of the project that then contribute to the larger whole.

Of course it is not just the desire to work closely with colleagues that has led to the growth of large-scale scientific collaborations and teams. In many ways we can say that changes in the problems that attract scientists' attention have made collaborations necessary. And these have not been limited to the world of science. More than 20 years ago, organizational behavior expert Barbara Gray listed many types of problems that lend themselves to collaboration in her book on management issues that arise from changes in the structure and functioning of large organizations. Interestingly while her list was not compiled with science in mind, the types of problems she identified as suitable for collaborative efforts are similar to those for which scientific collaborations are also appropriate (3). Some of them include ill-defined problems, the existence of disagreements regarding definition(s), problems characterized by technical complexity, issues with ambiguity of scientific findings, situations that do not yield to unilateral or unidisciplinary efforts, and challenges where existing approaches are insufficient. There are multiple examples of the tremendous impact that a successful collaboration can have, such as the discovery of the causative agent for Severe Acute Respiratory Syndrome (SARS) (4) and the successful development of the HPV vaccine (5).

Research organizations are increasingly enthusiastic about collaborative approaches and are encouraging their faculty and staff to work in a more integrative fashion in recognition that teams are likely to have a faster and fuller impact than an individual can achieve working independently. Infrastructure is being put in place both by institutions and funding agencies to promote more interaction, such as the building of large open labs where multiple researchers with similar interests can work in close proximity. The sharing of ideas through the creation of interdisciplinary work groups, and joint ownership of research projects is also now possible with the ability to submit grants as co-PIs to the National Institutes of Health

(NIH) (6, 7). It is noteworthy that voluntary cooperation is being seen among institutions that would otherwise be considered competitors in many ways.

In an extensive study of collaborations in physics, Shrum, Genuth, and Chompalov identify four factors that contribute to the impetus to form collaborations (8):

1. The inter-personal context (relations among scientists)
2. The funding context
3. The sectoral context (academic, corporate, governmental)
4. The context of participating organizations (university departments, research labs, etc.)

While all these aspects of collaborative work are very important, we will focus primarily on what they call the *interpersonal context* – the direct interactions and communications among scientific collaborators and those factors that contribute to the successful leadership and conduct of collaborative and team science, with occasional passing references to the policies and practices of university departments and corporate and governmental labs.

Characteristics of Effective Teams

It is relatively easy to cite examples and refer to scientific accomplishments that represent and demonstrate the value of scientific collaboration. It is much more difficult to identify in these examples the specific skills and approaches needed to spearhead or participate on a successful highly collaborative and integrated research team. In order to learn what skills and abilities both team leaders and participants possesses as active contributors to successful team science we performed in-depth interviews with NIH researchers who were part of five teams that either were successful, did not succeed in getting fully off the ground, or came to an end due to conflict. This approach enabled us to identify both fundamental characteristics critical for effective team functioning, as well as more complex elements that provided insights into what contributes to success and the inherent challenges of collaborative research. When we use the terms “successful” and “effective” we are referring to teams that develop a reasonable level of cohesiveness and that manage to pursue their missions. We do not mean to imply that the science was “correct” or that the results they achieved are those for which they hoped.

There are a number of fundamental elements that, when tended to by the leader and participants of a team put that group on a productive path and support the group’s scientific goals (Table 1). Theoretically speaking, these elements appear obvious and at the intellectual level they are extremely intuitive. However, in practice, these facets can be difficult to conceptualize and truly challenging to execute in the everyday practice of performing research because they require not only developing self-awareness, but changing behavior and learning new approaches and practices for bringing together others to shift a paradigm, solve a complex scientific problem, or meet a deadline.

Moving from Theory to Practice: Self- and Team-Awareness

Taking the knowledge about what needs to be done and translating it into how one routinely does business in the laboratory setting requires both tremendous self-awareness, as well as an awareness of the personalities, tendencies, strengths and weaknesses of those with whom you work. It also requires understanding what happens during the formation of teams and the importance of each of the steps on the path to high integration and interaction among the members.

Developing self-awareness about how you operate, such as your communication style, approach for managing conflict, personality type, and how you give and receive feedback, is an important first step. The next step is broadening this self-awareness across the entire team to achieve a shared understanding of the most effective and efficient modes of working together. In other words, self-awareness can provide a foundation for self-control in a wide variety of situations. One can self–regulate his or her reactions to others and events to focus on the issues at hand while managing potentially disruptive emotional reactions. This keeps discussion centered on ideas and greatly restrains the impacts of the affective component. The last step is assimilating all the learning and skill building and integrating it into how you "do business," which typically means developing some new habits and the motivation to incorporate them into your routine practices.

Short of years of psychotherapy, there are many tools available to efficiently assess your current styles. For style when in conflict there is the Thomas-Kilmann conflict mode assessment (9), and for personality types, there is the Myers-Briggs personality type indicator (10) and the 360° assessment for multiple facets of individual leadership (11). The important thing is not to classify people into different personality types but rather to be aware of the vast differences in ways of thinking, feeling and perceiving and to understand how these translate into different preferences in interaction with others. People often start with a 360° evaluation to obtain feedback about how others, at all levels, perceive them. Based on this input, priorities can be established for what new skills to learn and which behaviors could be modified.

Understanding Team Development

When a new team is formed or an existing team experiences changes in membership, understanding the dynamics of team development prepares the leader and the participants for managing the process. In the 1960's, psychologist and group dynamics expert Bruce Tuckman introduced and described four regularly occurring stages of team development: forming, storming, norming and performing (12). This work did not come specifically from studying scientific teams yet the characteristics and key points are highly applicable to the scientific setting.

Forming: During the forming stage the team is established using either a top-down or bottom-up approach. It is at this stage that the key scientific ideas and incipient hypotheses are formulated and potential participants in the team/collaboration are identified and invited. Forming is often a period of great intellectual excitement mixed with attention to formal organizational requirements, concerns about funding. Once the team has been officially "formed" it moves to the storming phase, where it takes shape.

Storming: During this phase team members establish roles and responsibilities delineate lines of communication, and generally develop the processes that will create a functioning scientific unit. This is the time when team members also move toward various degrees of interdependence. Understandably this process may tap into wariness about diminished autonomy as well as trigger disagreements or turf battles. Having to take into account perspectives other than one's own often is experienced as a threat to one's own well-established ways of thinking and doing and can be manifested as a reluctance to appreciate the perspectives and contributions of people from different disciplines or training. One of the most important tasks of a leader is to help people appreciate the potential value of differences that might otherwise appear to be threatening. Ironically this does not require an insistence on harmony and consensus but rather the creation of an atmosphere in which collegial scientific disagreement is valued and supported and

premature pressure to consensus is resisted. In these circumstances, people will begin to open up to one another.

Norming: During the norming stage team members begin to work together effectively and efficiently, start to develop trust and comfort with one another, and learn they can rely on each other.

Performing: At the performing stage the team works together seamlessly, focuses on a shared goal, and efficiently resolves issues or problems that emerge.

While the forming stage centers on the scientific base for the team's work, successfully navigating the storming phase is the most critical for truly effective team functioning. It is during the storming stage that the threats to one's status, power, and autonomy come into play and can provide the basis for the sometimes significant positioning among team members (13). For an individual moving into teamwork, the threats include experiencing one's status as a member of a group as opposed to being viewed as an individual or *the* sole expert, sharing power and control of a project with others, and becoming interdependent.

The major tasks to accomplish during the storming stage include developing a shared vision, implementing processes for managing conflict while creating a safe space for open and honest discussion, articulating expectations and defining roles and responsibilities. Those teams that successfully get through the storming phase emerge on the other side with much stronger trust and can then slide into the norming phase. Some teams never get past storming.

Trust

Based on our research, practical experience, and literature reviews, we firmly believe that trust plays an essential role in the functioning of teams and the effectiveness of collaborations. Trust is not an easy matter to discuss with scientists. For many it seems hopelessly subjective and even softheaded. Besides, talking about trust inevitably means analyzing relationships and most scientists want to focus their attention on the scientific problems that drive their research, not their working relationships with their colleagues. However, especially as science becomes more complex and research benefits from cooperative work among people with different areas of expertise and trained in different sub-specialties, the dynamics of work relationships play an increasingly important role in the scientific research itself.

Consider the simple fact that participating in any joint venture means relinquishing some of one's individual control or power over the outcome of that venture. When one collaborates one has partners who now have a say in the decision-making process. Furthermore, the performance of each individual member has impact on overall team performance; there is mutual dependence. Dependence begets vulnerability and, without trust, vulnerability leads to protective or defensive rather than collaborative action. Scientific collaborations are especially interesting because they occur not just among people whose areas of expertise are complementary but also among people who are competitors or potential competitors. To work together competitors must give up some of their autonomy, and so must have confidence that their mutual interests will take precedence over their individual interests. We believe that trust, whether grounded in a strong personal relationship or created and reflected in a written agreement, plays a critical role in the functioning of scientific teams and collaborations.

To understand trust it is helpful to distinguish three different types of trust. The most personal form of trust can be called *identity-based trust*. "At this level, trust exists because the parties effectively understand and appreciate each other's wants, desires and values; this

mutual understanding is developed to the point that each party can effectively act for the other" (14). In most daily interactions and transactions we rely on a less personal form of trust – *calculus-based trust*. This is the sort of trust that is engendered when we interact with people who keep their word, meet deadlines, and fulfill the expectations agreed upon in our communications with them. Such trust is not dependent on a deep personal understanding between people but, over time, it can contribute to the development of a personal bond. Finally, and this is particularly important in the world of science, there is *competence-based trust* (15). Competence-based trust is built around the confidence we have in the capabilities and skills of another person. This is the sort of skill that is referenced when a PI asserts that her technician has "good hands." While this sort of trust is also not especially personal, it can, in a long-term working relationship, contribute to the growth of a deeper, more personal trust between collaborators. At the same time, we should note that the erosion of calculus- or identity-based trust can also lead to doubt about another's competence.

In thinking about the importance of trust we must consider two aspects of effective team functioning: cohesiveness, as well as scientific quality and productivity. In science, as in most activities, cohesiveness alone is not enough to consider a team as successful. Clearly, while high levels of trust can contribute to high levels of team cohesiveness, cohesiveness is in no way a guarantee of quality or productivity. Trust then is a necessary, but not sufficient, condition for effective performance by scientific teams. There is considerable social science research that demonstrates that trust has a significant impact on team performance. We appreciate Kirk and Ferrin's suggestion that "trust … provides a representation of how individuals understand their relationship with another party in situations that involve risk or vulnerability" (16). They describe how trust affects both how we assess the behavior of another person and how we interpret the past and present actions of the other party. In turn these assessments affect motivation levels and cooperativeness among team members. Of course the effects of trust are not only interpersonal. In research, trust becomes especially important because it has an impact on team members' judgments about another's abilities, designs, observations and scientific results.

When one loses trust in a colleague everything that person does becomes suspect. And in science, confidence in another's intentions and commitment is just one aspect of trust. Think of the impact in a research team when people began to doubt the data produced by a team member. Even if there are no questions at all about an individual's character, it is almost impossible to work effectively with a colleague whose work itself is not trusted.

For all these reasons we would argue that it is important for those forming teams and building collaborations to take specific steps to proactively build trust rather than just hope that it emerges spontaneously from the interactions among team members. As in other building projects, construction begins with scaffolding. For scientific teams the scaffolding is made up of explicit statements of understanding among the participants in the team. We suggest explicit conversations during which prospective partners spell out what they expect of one another, how data and materials will be shared, who will do what, how decisions will be made, and how disagreements or conflicts will be resolved. In addition, providing explicit policies and procedures that all members of the collaboration are expected to follow establishes a platform for calculus-based trust. But even the best designed policies and procedures need thoughtful implementation to engender the sort of trust necessary for a scientific team to flourish. It is in interactions and communications while building a team that this trust is formed.

Building a Team

Building a team is always an exercise in managing differences and embracing diversity. This is especially the case in research teams, which bring together individuals from various disciplines and specialties, at different stages in their careers, and often from different institutions as well. Also, in the world of science, most scientific teams are composed of men and women of different races, ages, nationalities, ethnicities, and religions. If we consider that a research team has to function collaboratively with the aim of addressing or solving a research question or problem, the challenge of forming a cohesive team with such diverse participants can seem rather daunting. At the same time, when managed well that same diversity is a powerful resource for a team because the very reason for forming the team is to bring together a multiplicity of perspectives on a problem (17, 18, 19, 20).

The first step in taking advantage of diversity is to identify people interested in working as part of an interdisciplinary collective. It is important to recognize that collaborating is not for everyone. When starting a collaboration or forming a research team it is important to assess people's capacities for collaborative work in addition to their technical abilities and scientific pedigrees. This can be done both through carefully designed interview questions and reference checks. Selecting team members is more than a matter of picking people with the right attitudes and basic skills for working with others. Factors such as commitment, willingness to share data, and their own self-awareness about how they would likely fare in a team environment are also important considerations.

A well put-together team is one in which there is some synchronicity between the overall goals of the team and the aspirations and career needs of the individual members. "What's in it for me?" is a perfectly reasonable question for a prospective team member to ask even of a tremendously exciting research venture. Of course we must be mindful of the fact that collaborations are composed of people at very different stages of their careers and that even the question "what's in it for me" means very different things depending on where one is in one's professional development and their career aspirations (21).

Teams that can support the professional development of individual members while working on a significant scientific problem obviously provide great incentives for team members to contribute to effective team functioning. This is in the very nature of interdependence – a situation in which participants cannot achieve their individual goals on their own and where by working together they have a greater chance of achieving their goals than were they to proceed individually.

Not surprisingly, there are also some challenges. The more established one is in his or her career path the more working collaboratively may be seen as a natural extension of one's scientific work and career. In contrast, many early in their careers perceive participating in interdisciplinary work as a risky (22). For graduate students, post docs, and junior investigators, as they move to the point of needing to establish themselves as a leader in the field and becoming responsible for shifting paradigms within a framework that is inherently based on the individual, trusting that the system will recognize their individual accomplishments as part of a highly integrated interdisciplinary team may seem risky. Review criteria for the evaluation of investigators participating in team science need to be robust and clearly articulate the requirements for a positive evaluation such that multiple leaders working together in a highly integrated approach where status and power are shared can be appropriately recognized and rewarded (23).

Creating a Shared Vision

Once the team leader has assembled his or her team, it is critical to engage the group in a discussion about the overall mission of the research project. Certainly the team leader starts with a vision, which can be self-generated, emerge from a group discussion, or result from a request by someone higher in the organization or a funder. The leader uses the articulation of the vision to recruit members to the team and, after its formation, engages the participants in further defining and outlining what we call the shared vision. The members of a team play an active role in developing a research agenda with a common sense of the overarching project goals and associated objectives. The group establishes a clear understanding of the roles and responsibilities of the different team members, helps determine how the various resources and activities will be coordinated to achieve the goals, and how the individual pieces fit together to create the larger whole.

Every team member must have some idea of the “big picture” and understand how his or her work fits into and contributes to the overall effort. We do not mean to suggest that everyone must see the end goal in exactly the same way. In fact, the various team participants will reflect their individual role in the team, the role of the organizational unit within which they are working, and a host of idiosyncratic factors onto their perspective of the desired outcome.

One of the hallmarks of an effective team leader is being able to articulate the scientific project vision to the research community and the home institution, as well as artfully nurturing individual member perspectives. The leader conveys the vision in a way that allows each of the members to recognize his or her contributions. This promotion and self-advocacy helps clarify the team’s overall direction, which is based on team member’s individual responsibilities, and catalyzes the focused energy required to accomplish the team’s objectives (24).

Vision statements and team objectives are dynamic and will change over time. In fact, they need to be regularly revisited and reevaluated. When surprises or unanticipated findings occur that put into question the current direction, meeting as a group to assess the current state of knowledge, plan next steps, and readjust the vision contribute greatly to the progress in supporting the goal. Continuing to engage the group in the discussions surrounding the direction of the research project, logical next steps, and how to address challenges or barriers assures that the strengths of every team member are used to their fullest.

Sharing Recognition and Credit

We strongly encourage collaborators to spell out the agreed- upon criteria for authorship on abstracts and papers, authorship order, how decisions are made about who gives talks, appears on TV, or gives radio interviews, who will respond to media inquiries, and how intellectual property and patent applications will be handled (25). Formally articulating how recognition and credit will be shared among members of an integrated research team takes some forethought, planning and agreement. Doing this at an early stage of the collaborative work can save many hours or even days of arguments and discontent should a disagreement about sharing credit emerge later with the creation of a product such as a journal article or an opportunity to present findings at a meeting. It is especially important for the team to discuss how they will promote the careers of junior colleagues and investigators, recognizing that in the context of the team research project, their scientific growth and development depends heavily on opportunities to take appropriate credit and receive proper recognition for their contributions (21, 22).

In addition, at the outset of a team effort members should agree on the steps that will be taken should a disagreement or conflict develop that cannot be resolved by direct communication between disputing parties. This might mean bringing in an outside mediator to help resolve disputes when discussion/negotiation among team members or PIs fails to result in agreement. Or it could mean creating a "governance committee" that has final decision-making authority when the collaborators are unable to agree. Whatever process is decided on it is always much easier to design a mechanism for resolving conflict before a specific one has developed than it will be after it erupts. As you can easily imagine, the role of trust in these activities is absolutely critical.

Communicating about the Science: Promoting Disagreement while Containing Conflict

A major goal of any collaborative effort is to create a safe environment for the discussion of hot button and controversial scientific issues. Trust, as discussed previously, provides a critical foundation for having open and honest discussions about the science without the risk of team members interpreting challenges or hard questions as personal attacks. Highly interactive and integrated team participants will have disagreements; this is actually something that should be nurtured in the context of highly productive exchanges. The goal is not for everyone to agree or to avoid conflict all together. The goal is to support the scientific disagreement while containing the personal conflict (26).

There are numerous benefits to engaging in disagreements, continuing the dialogue, and working the issues through with valued collaborators. Among them: new and stronger relationships being built within the group; keeping problems or issues from accumulating; preventing resentment from growing over time; the continued re-evaluation of the group dynamic and the rules to be followed; strengthened trust; and the emergence of new creative solutions to pesky problems.

Miscommunications and conflict will occur in groups, however the impact can be greatly minimized through both anticipation of and knowledge about how to manage them. As mentioned earlier, it is tremendously valuable not only to understand the different ways individuals react to conflict but also to understand our own individual styles. This is especially true when people are in stressful situations, as they will often quickly move to the interactive style that is most comfortable for them.

The five conflict-handling styles presented and discussed in the Thomas-Kilmann instrument mentioned earlier include avoiding, accommodating, competing, compromising, and collaborating. Each style is perfectly appropriate in some situations and not at all effective in others. As a leader or participant in a team science or collaborative project, having the skill to select the style and behavior appropriate for the given situation can take work. Learning how to use this conflict management 'toolkit' can provide a great return on the time required to master the task. A companion paper in this series by Zucker clearly articulates a strategy that can be used to successfully manage conflict situations (27).

The only people more foolish than two people falling in love are scientists starting collaboration. When passionate about an exciting scientific idea, scientists often neglect to think realistically about the multiple tasks that will need to be accomplished to construct an effectively functioning scientific team. All too often collaborative relationships are derailed by conflicts that emerge because potential tensions, differences and difficulties were not identified or discussed at the outset of the collaboration. A collaborative research agreement can pull together many elements discussed in this paper into an overall agreement for how the various collaborators will work together. It will clearly set expectations, outline roles and

responsibilities, provide contingencies should conflict arise, and state authorship criteria (Table 2).

Yet, our suggestion of establishing collaborative agreements has met with much resistance, especially when it is viewed as something that will take valuable time away from the scientific effort. However, it has been our experience that spending a small amount of time discussing these elements at the start of a collaborative arrangement will greatly diminish the chance of spending vast amounts of time later trying to untangle heated discussions and hostile conflict situations when things go wrong, which sadly often happens. Even a short email after a discussion recounting, summarizing and reinforcing a face-to-face conversation can serve this purpose quite well and multiple such correspondences can be combined to generate a mutual agreement for the work together.

Creating an environment in which respectful disagreement can occur, productive discussion around difference is fostered, and all while conflict and negative emotion is contained, can lead to enhanced shared learning and focus everyone's efforts on the scientific project at hand.

Communicating with Each Other

Scientists can become impatient when we start talking about things like team dynamics and trust. A typical reaction would include their saying that these things are either obvious or very difficult to get one's hands around. Not surprisingly, scientists would rather be doing science than concerning themselves with discussions about how they are all getting along (28).

Table 3 lists several suggestions for strengthening team dynamics. Although the final suggestion of scheduling periodic assessments and feedback often elicits resistance, it can be very helpful to team functioning. People who work together can be reluctant to "rock the boat" by bringing up problems or discontent. Such reluctance is often an indicator of a potentially serious problem that is better attended to early rather than sitting on it in the hopes that it will go away. Interestingly, once a team gets into the habit of conducting regular assessment and feedback sessions, these become much easier to conduct and their value becomes apparent. For those reluctant even to use the terms "assessment" or "evaluation," even establishing a routine as simple as "checking-in" with one's colleagues at the beginning and end of a meeting can be helpful. One could just ask each person at the meeting, "Are there any problems or concerns that need to be attended to?"

Enjoying the Science

All you have to do to find out what makes a scientist tick is to ask if he or she would be willing to tell you about their research projects. When we started to learn more about what makes collaborative research teams successful, we quickly found that it is not dissimilar from multiplying that individual enthusiasm by two or three or more. For many scientists, being able to share the excitement of the research process and discovery, especially with others for whom it is also exciting, is extremely rewarding.

Several leading thinkers have reflected upon the joy they encountered in their collaborations. Psychologist Daniel Kahneman, who won the 2002 Nobel Prize in economics, described the satisfaction and enjoyment he experienced in his collaboration with psychologist Amos Tversky this way: *"[W]e met in Jerusalem to look at the results and write a paper. The experience was magical. I had enjoyed collaborative work before, but this was different. Amos was often described by people who knew him as the smartest person they knew. He was also very funny, with an endless supply of jokes appropriate to every nuance of a*

situation. In his presence, I became funny as well, and the result was that we could spend hours of solid work in continuous mirth … [A]nd we were not just having fun. I quickly discovered that Amos had a remedy for everything I found difficult about writing. With him movement was always forward … [A]s we were writing our first paper, I was conscious of how much better it was than the more hesitant piece I would have written by myself." (29, 30)

We have heard from many researchers that a good collaboration provides many benefits beyond strengthening the actual science. They cite many intangible elements, such as complementarity of work styles and approaches, improved quality of the experimental design or analysis of the results, and strong personal connections to colleagues, which are not merely supportive but also deeply enjoyable and satisfying. There are not many things more satisfying than doing what you truly love, sharing that passion, and working closely with others who are pursuing the same goals.

Case in Point

The discussion case presented in the introduction to this and the two companion articles, is used here to illustrate how an approach can be developed that takes the principles presented in this article and puts them into practice. Through group meetings buttressed by email exchanges the team can begin to establish the trust necessary to get them through the storming phase and eventually to the level of performing as a highly integrated research team.

Drs. Ally and Chase will need to have a conversation to decide how the team will be led. A major question is whether there will be a primary leader or co-leads. Dr. Ally, aware that since being tenured she is frequently on travel, may be receptive to a co-leader approach where she and Dr. Chase work closely to share leadership for the effort. This will require frequent one-on-one discussions between Drs. Ally and Chase in addition to those with the larger group. The next step is to decide on the overall goal of the project and the associated objectives that will contribute to achieving that goal. Once the goal is more clearly defined Drs. Bond and Day can be brought into the discussions. This will set the stage for the inclusion of their lab personnel who will also be working on the joint project. Group meetings focused on the project goals will benefit from broad input since it provides opportunities to capture elements that might have been overlooked and it help creates an atmosphere where people begin to trust one another, perceive their contributions are valued, can share their strengths, and learn from the others.

After the objectives have been identified it is critical to have conversations about roles and responsibilities as well as expectations. Given the details of the case discussion, and the concerns Dr. Chase has about working with Dr. Ally, it will be important for them to delineate clearly which decisions each has the final say on. Typicall this will be matters dependent on their individual areas of scientific expertise. In addition, identifying the team members who will be involved in achieving each of the objectives, making sure everyone understands their roles and those of others, who to go to for clarification, help, or more information contributes to strong team functioning.

It is critical for the key leaders to agree upon meeting schedules and discuss how meetings will be handled if someone is absent or travelling. Who will lead the weekly meeting? Does the meeting go on if Dr. Ally is travelling? How will they keep everyone up to date on what happened at the meeting? Developing standard agreed upon procedures for how reagents are made and shared, data is shared, and problems are addressed and whether they are solved helps create the calculus-based trust critical for early stages of team development.

The four doctors need to have an open and honest discussion about authorship. Spending time agreeing on the criteria for the various authorship positions on abstracts or papers will prevent disputes and keep people from making assumptions. In addition they should develop a clear process for reviewing drafts and an understanding about the approval process prior to any submissions. It is also helpful to discuss who the spokespeople will be should the media call after an exiting result is published. Slowly turning the agreements made during meetings or through email exchanges into written form provides another tool for starting to build strong trust among team members and more importantly provides a document that can be revisited, revised, and restructured as needed over the course of the collaboration.

Finally, if the team gets through the storming and norming phases and truly hits their stride in working together, identity based trust will have formed and the group should consider ways of acknowledging their enjoyment in working together whether it is celebrating an accomplishment, going for lunch, or some other activity.

Conclusion

There are many factors that come together and contribute to successful collaborations. Just as there is no one formula for successful leadership, there is no one formula for establishing an effective team. Some of the characteristics we have noted in effective team functioning include internal cohesion, productivity, the ability to communicate openly and learn each others languages, setting shared expectations, defining roles and responsibilities, and challenging each other without it becoming personal.

Trust is among the most critical elements we have encountered that influence team cohesion in our research and practice. While a group can come together and work on a joint project without having established trust, it is very difficult for a team to continue working together toward a common goal without establishing it. Other essential elements include creating a strong vision, sharing recognition and credit, handling conflict, building the team, and of course, having fun. Communication is extremely important and not surprisingly cuts across all the above aspects. There are many aspects to communication that are important to recognize extending from simple logistics of how to communicate, which cannot be understated, to talking about the science as well as establishing, strengthening and maintaining team dynamics.

Team participants can play key roles in collaborative efforts. They often provide critical support and can even fill gaps in the skill set of the leader, reinforcing the value of self-awareness, both on the part of the leader as well as the participants. If a leader knows he or she can clearly articulate the overall vision and direction, yet has difficulty clearly setting expectations and providing details for team members to follow, he or she can find someone to join the team who can take a lead role in assuring these critical elements are managed well.

From our perspective, the most important focus for highly integrated and interactive teams is to spend their time fully engaged in the research and the scientific process. There is no better time than now to bring together people from different disciplines and backgrounds to solve highly complex scientific problems. With a handful of strategies in each scientist’s toolkit, the focus can stay on the scientific problem at hand and the challenges minimized in order to benefit from the diverse contributions of an interdisciplinary team.

Acknowledgments

We thank Samantha Levine-Finley, Associate Ombudsman at the National Institutes of Health, for her contributions to the effort to capture the critical elements that must come together for successful team functioning.

This work was supported in part by the Intramural Research Program at the NIH.

Sponsored by the American Federation for Medical Research

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Appendix

INTRODUCTION

Productive Translational Research: Tools for Connecting Research Cultures and Managing Conflict

Interdisciplinary, translational research brings with it the challenge of integrating researchers from different personal and professional cultures into dynamic and productive research teams. Many factors, such as building trust, identifying the right team members, good communication, and effective negotiation are needed to advance collaborative projects and to prevent and manage disputes and conflicts. At the 2010 Experimental Biology meeting in Anaheim, CA (April 24, 2010), the American Federation for Medical Reseach-Translational Research Career Development Workshop, *Productive Translational Research: Tools for Connecting Research Cultures and Managing Conflict*, focused on strategies for building successful research teams. It also addressed issues of individual career development in an age of team science, as well as presenting tools one might use in productively managing conflicts. The following articles present the workshop topics. Below is a discussion case that was presented to the workshop participants and slides from the presentations are also available on the American Federation for Medical Research website: http://www.afmr.org.

DISCUSSION CASE

Dr. Ally - Background

Dr. Ally is a Caucasian-American, recently tenured professor and physician scientist at Acme University. Dr. A's laboratory employs 4 postdoctoral fellows and 10 research technicians and associates in her large laboratory. She has always been committed to weekly lab meetings with her lab members and collaborators, but since she secured tenure, she has found it harder and harder to make the time to meet regularly.

Dr. Ally travels frequently to speaking engagements at conferences and universities, serves on a National Institutes of Health study section, and is a senior officer in a national research organization. She has an outgoing personality and is very intuitive in her approach and skilled at getting people to do things for her. She relies on her senior trainees and research associates to manage the day-to-day operations of her laboratory. Dr. Ally visits her laboratory on a regular basis to review research and chair planning meetings. She is currently well funded with several grants from various organizations.

Dr. Ally has worked for several years on the development of a new highly effective statin that reduces cholesterol and significantly reverses atherosclerosis with minimal side effects.

The drug has been tested in animals and the results look promising. Dr. Ally and her research team now want to begin clinical trials.

One year ago, Dr. Ally became involved with an industry start-up company with an interest developing a product line of pharmaceuticals that provide multiple benefits to patients with chronic illness. They believe that Dr. A's new agent has strong market potential for Type II diabetics and others with hypertension.

Dr. Bond - Background

Dr. Bond is a South Asian, postdoctoral fellow in Dr. A's laboratory. Dr. Bond has been a post-doctoral for 2 1/2 years while other post-doctoral fellows have been in Dr. A's laboratory for more than 4 years. Even though he has spent less time as a post-doctoral fellow, he feels ready to pursue independent research in an academic setting and hopes to secure grant funding that will enable him to start his own laboratory in the near future. An outstanding letter of recommendation from Dr. Ally will be critical to secure this competitive award.

Dr. Bond has played an active role in the development of this new statin. Dr. Ally and Dr. Bond have collaborated on several papers about the drug. It was Dr. Bond who discovered that one specific formulation under development in their laboratory showed the greatest potential for reversing atherosclerosis. He is currently writing a paper with Dr. Ally on the interaction that produces this result. Although Dr. Bond has not discussed this with Dr A, he is confident that his level of contribution to this paper will result in his being named not only as first author but corresponding author as well. He thinks that this paper will serve as a positive conclusion to his fellowship.

Dr. Bond's proposed research to further explore the interaction he discovered will require use of the reagent he developed in Dr. Ally's laboratory. Dr. Ally has suggested several times that Dr. Bond continue his good work as an employee at the company with which she is involved and has assured Dr. Bond that her good relationship with the company could help him attain a position there.

Dr. Chase - Background

Dr. Chase is a senior tenured professor and a clinician researcher at Acme University. Dr. Ally recently approached to discuss the possibility of their collaboration on the clinical trials of the new statin developed in Dr. A's laboratory. Dr. C's practice includes a large number of Type II diabetic patients with high cholesterol and atherosclerosis. Dr. Chase and his staff would need to find and recruit a sufficient number of these patients for the clinical trial. This will be a first in human trial. Dr. Chase is interested in the concept of the proposed study based on the data and information presented to Dr. Chase by Dr. A. However, because Dr. Ally has very little experience with clinical trials and he is dubious about her expertise, he is wary of collaborating with her. In addition, Dr. Ally seems to be an expert in self-promotion, which also causes him concern. In spite of these concerns, because the proposed project is potentially very important he agrees to explore the possibility of working with Dr. Ally.

Dr. Day - Background

Dr. Day is a tenure track assistant professor and biostatistician from Eastern Europe. She is well regarded for her ability to determine sampling and data collection methodologies. Dr. Chase met with Dr. Day and asked if she would be interested in assisting with monitoring the execution of the new statin clinical trial and providing advice on the strengths and limitations of the design and should they get to that point, the results. Since Dr. Chase

arrived at Acme, Dr. Chase and Dr. Day have collaborated on a number of clinical trials. They have a history of working well together. Dr. Chase enjoys Dr. Day's direct style of communication and sense of humor.

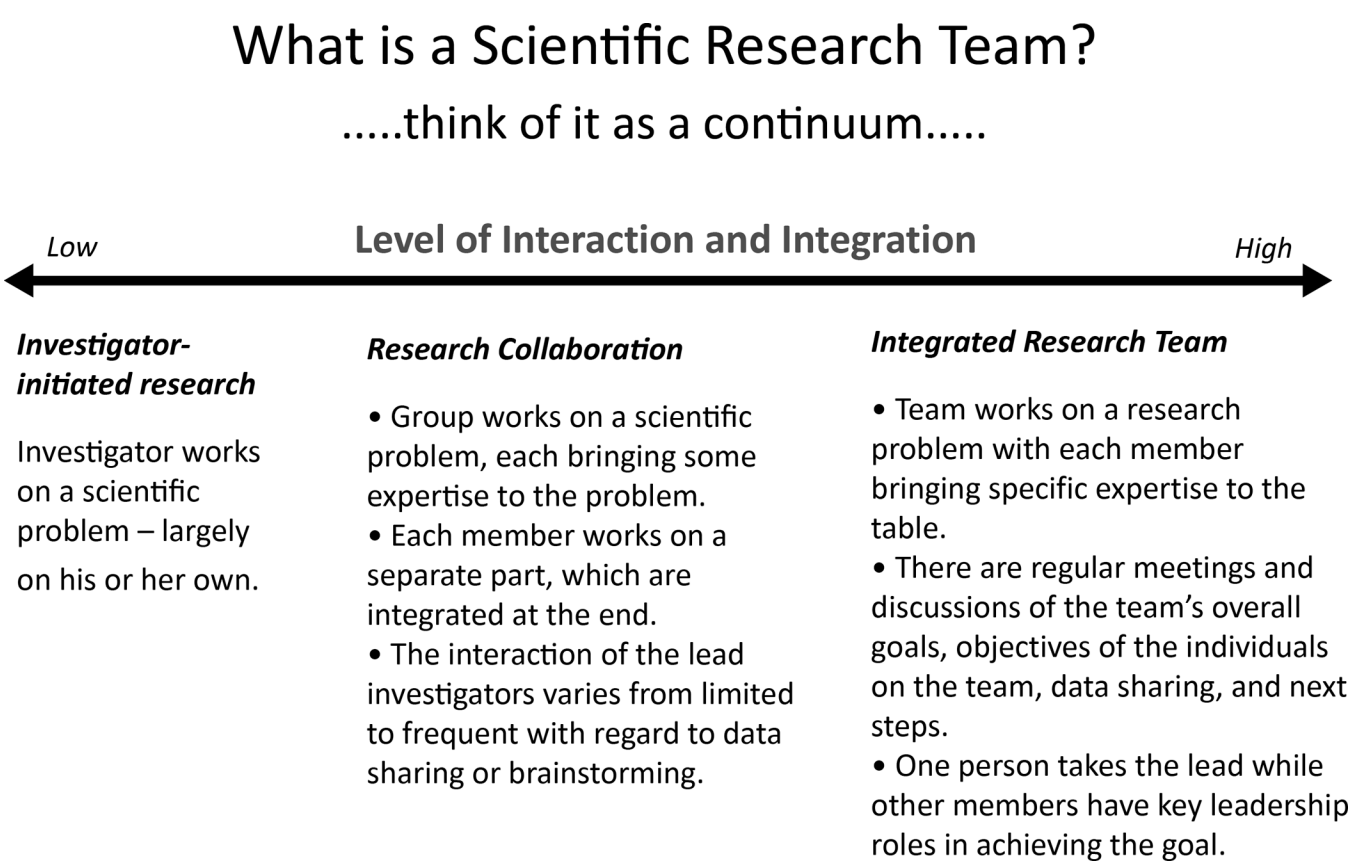

Figure 1.
The degrees of interaction and integration for a research team exist along a continuum extending from low levels to high levels.

Table 1

Characteristics of an Effective Team

• Effective leadership and management skills
• Self- and other-awareness
• Trust is established among team members
• Strategies developed for communicating openly
• Effective building of a team, including setting shared expectations and defining roles and responsibilities
• Creating, sharing, and revisiting a shared vision
• Making provisions for appropriate recognition and credit
• Promoting disagreement while containing conflict
• Learning each others' languages
• Enjoying the science and the work together

Reference (28)

Table 2

Collaborative Research Agreements

Categories to cover
• Goals of Collaboration • Including…when is the project “over”?
• Who Will Do What? • Expectations, responsibility and accountability
• Authorship, Credit • Criteria, attribution, public comment, media, IP
• Contingencies and Communicating • What if …? and Rules of engagement
• Conflict of Interest • How will you ID conflicts? And resolve them?

Template available at: teamscience.nih.gov (25, 28)

Table 3

Ways to Strengthen Team Dynamics

Foster an environment that is collegial and non-threatening
Openly recognize strengths of all members of the team and discuss how these different strengths contribute to advancing the project
Take a few minutes at regularly scheduled group meetings to do a check-in. Ask how everyone is doing.
Encourage open and honest discussion by establishing trust
Jointly develop a process for bringing issues and disagreements forward for early resolution
Assure that when decisions are being made that require everyone's input that each person has an opportunity and understands the process for providing comment
Schedule periodic assessments and feedback, including opportunities for collaborators to discuss what is going well, what is not, and what needs to be improved.