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Scientific Production: An Exploration into Organization, Resource Allocation, and Funding

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DISCIPLINE REPORTS

Astronomy………………………………………………………………………………………... 1
Biochemistry………………………………………………………………………………………… 4
Geosciences………………………………………………………………………………………. 10
Mechanical Engineering……………………………………………………………………….. 16
Molecular Biology……………………………………………………………………………... 19

Astronomy

Sample

- 3 Professors, all tenured, all superstars, one involved for a decade in the Large Synoptic Survey Telescope (LSST)
  - Experimental physicist
  - Astrophysicist
  - Astrochemistry

Main Similarities

- All noted the following:
  - The new survey telescope (LSST) is bringing a sea change, changing the environment. It is changing the way topics are chosen, what is shared, and research planned. The new scarcity will be ideas rather than code or data.
  - The field has healthy competition except for funding.
  - Fairly open and ethical field.
  - Commercial potential is of little importance.
- Two of the three identified spawning topics and projects for current and future students as very important in choosing topics.
- Two of the three had a manager; the people were technicians without management training.
- Funding was the most important in determining lab size, with PI time next in importance; nature of research was relatively low.
- Role of helping science or the public.
  - One has done critical work on the LSST and views influencing science in the field as very important.
  - Two of the three interviewed said finding results of public interest was a goal (such as discovery of the Higgs Boson).

Main Differences

- The role of publications, particularly probability of success in a top ranked journal, was ranked highly by one, but less highly by others.
- Researchers disagreed on how they would spend money if they suddenly received double the funding.
  - One would double students and postdocs, one would double postdocs or research scientists, and one would add it all to equipment.
  - Two would not change research direction other than doing riskier projects.
  - One would use the postdocs to ask if there are new research streams that could be done with the increased funding.

Laboratory ("Astronomer's Lab" – Observatory)

- Physical labs
  - Yes, with two saying observatory.
  - One used observatory plus had an experimental lab
- Number of people
  - (1) Largest group: 20
  - (2) Smaller groups: 10 and 4
- Lab manager
  - Two had a lab manager with no formal training in management
  - The third said lab manager was more of a bio lab thing
- Determinants of lab size

    - All said funding was the most important determinant of lab size.
        - Second most important factor was PI time.
        - Space allocation least important, with nature of research topic of middle importance.
- Lab goals
    - One identified maximizing publication as the most important.
    - Two said launching new careers and creating knowledge as most important.

Research Budget Allocation

- Equipment ranged from 20 – 33 %
- Students accounted for 20 – 40%
- Postdoctoral fellows were around 10% for the lab with 40% for students; 40% for the lab with 20% for students.
- In essence, labor inputs were 50-60%.

Research Topics

- Choosing topics
    - Spawning projects for students was important.
    - One noted that a strategic decision was made years ago to go in a particular direction because it "would surely provide projects for years to come."

Evaluation

- No clear milestones
- One said that the research group assesses projects periodically. "A collective assessment of progress relative to the goal."
- All three appear to work with students rather than judge on publications.

Knowledge and Information Sharing

- Sea change with the new Chilean survey telescope
- Preprints are very important as well as publications in disseminating knowledge
- Value in sharing not to be scooped.
- One said, "Most people are not foolish enough to work on a problem we are working on."

Collaboration Patterns

- Collaboration was viewed as a way of allowing for a broader portfolio of projects at the same time.
- All collaborated when there were skills not in their lab. Otherwise wanted the minimum number of collaborators.
- Two noted the luxury of being picky; one met collaborators at meetings.
- These interviewees were highly successful. Two said "the jerk" factor was important. They avoided working with people they did not like because they could attract others. One admitted to avoiding certainly subfields as a junior faculty member because of the "jerk factor."

Competition

- Competition viewed as healthy
- Becoming fiercer for funding; it would be better if that were less.

Equipment and Funding

- Hypothetical Situation of Receiving Double Funding
- Research Direction

- All said no, but…
    - The astrochemist would conduct new experiments from scratch which would be riskier
    - The astrophysicist would likely hire postdocs and would ask "is there some new interesting research direction that we're not currently pursuing that the new funding would allow us to pursue."
    - Input ratios
        - Two would double labor
            - One would take on new students and postdocs
            - One would hire postdocs or research scientists
        - One would double equipment because the PI has the lab size she can handle
    - The PI who would double equipment
        - The PI has maximum group size can handle.
    - The PIs who would double labor
        - Split among postdocs and students
        - Double the effort

Biochemistry

Sample

- 7 Professors/Researchers
  - Biochemist
  - Biochemist with a specialization in structural biology
  - Biologist/Biochemist
  - Biophysics
  - Biochemist Biologist
  - Protein Scientist (Biologist)
  - Biochemist

Main Similarities

- None of the interviewees had a professional manager in charge of their lab. This was mostly done by either the PI or a postdoc.
- Interviewees identified funding as the most important aspect in determining lab size.
- Maximizing the number of publications in top journals was identified as the top priority in terms of lab goals.
- About 2/3 of the budget goes to paying staff salaries.
- Researchers were typically not very interested in the commercial value of their research. This goes in hand with solving "real world" problems, given that these types of problems are the ones that usually have commercial value.
- Researchers believed that tackling the most challenging questions and publications were the most important determinants for choosing research topics.

Main Differences

- The importance of likeliness of success as a determinant of research projects yielded the most differences among researchers. Some did not even consider it as a factor, while others only undertook a project if they were confident that it had publishing potential.
- Researchers disagreed on the impact that another team answering a question had on their projects. This was primarily related to the scope and/or specialization of the of the research area.
- Researchers disagreed on the importance of top journals or citations as a method of evaluation. Answers ranged from important, somewhat important, and not important.
- Researchers disagreed on how they would spend money if they suddenly received double the funding. Some stated that they would hire more people, while others would buy more equipment.
- Researchers were also heterogeneous with respect to how they would respond to supply shortages. Some would have to stop entirely, while others would be able to build their own equipment or find suitable supplies.

Laboratory

- Number of people
  - Four researchers have large labs (20 – 40 people)
  - Three researchers have small labs (6 – 9 people)
- Lab manager
  - Researchers did not employ formal lab managers. Most of them were either managed by a "technician" or by the PI.
- Determinants of lab size
  - Researchers identified funding as the most, or one of the most, important aspects in determining the size of the lab.

    - The second most important factor was PI time, although they point out that this largely depends on the amount of funding.
- Lab goals
    - Maximize publications/scientific reputation along with creating new knowledge were identified as the most important lab goals. However, not all PIs focused on the number of publications; rather they focused on the quality of the publications.
        - "Publications is basically the product of our work. This is the measure by which others are determining whether we are successful or not, whether we are doing a good job or not, whether we are using the funding properly and effectively." (Subject 7)
        - "The quality of research is extremely important I would say that the number itself is not so much important but the quality of the publication is much more important. So I would rather have few, but high-quality publication" (Subject 3)
    - With a few exceptions, researchers were not particularly focused on attracting the best students. This is often desired, but not a requirement.
        - "of course you try to get them but I wouldn't say I go to very long lengths in getting them. I do not for example, chase away people who have not the best marks" (Subject 1)
        - "I would say that's key, but as a starting lab you don't always have the option to get the best people." (Subject 5)
        - "We are trying to attract the best possible students, which is only possible if our work is going way better because the students, the best ones, they will join the lab where they feel that it provides them the best opportunity to be successful." (Subject 7)

Research Budget Allocation

- Researchers stated that they spent most of their budget, between 3/4th and 2/3rd, on salaries as opposed to equipment.
    - "It's the most important, largest portion. So typically, salaries are the biggest item in any grant budget" (Subject 2)
    - "So it's probably around sixty percent for labor and forty percent for material including equipment." (Subject 3)
    - "I would say we spend probably at least two certs thirds on personnel costs. It's a major cost factor and it has continuously increased over the years due to salary increases" (Subject 7)

Research Topics

- Determinants of research topics
    - Tackling the more challenging problems in the field (5) in combination with funding are the most important determinants of research topics (3).
    - Researchers were in disagreement regarding the importance of the likelihood of success as a determinant of research topics. Some researchers believed that risky projects typically lead to other research questions, while others believed that all projects typically lead to publications.
        - "I actually don't mind much about the likelihood of the success of the full project, I usually see always a lot of interesting questions on the way." (Subject 1)
        - "I would say four out of five. I think it's pretty important. But then there are low hanging fruits projects that I know they will work and they're like the higher risk, high gain projects that are exciting." (Subject 5)
    - One researcher pointed out that funding was not an issue:

        - "Fortunately, in the [Institution Name] it's not that important because we usually have sufficient funds to at least obtain preliminary results on a certain project." (Subject 7)
    - There were mixed answers regarding the important that spawning dissertation topics for students as a major determinant of research topics. For some it was seen as byproduct of a larger research question. Other PIs mentioned that most projects are designed as dissertation projects.
        - "most of the projects are designed as dissertation projects right, so one person will be the main driver and they will set it up so this kind of happens very organically" (Subject 3)
        - "Without having such dissertation projects, we basically couldn't really do the work"
    - One of the researchers believed that commercial potential was a significant factor. This was in line with having applications outside of academia. Three researchers believed that solving a "real world" problem was important, given that the intention of the research was to eventually enter a clinical avenue.
- Determinants of ending a line of research
    - There was disagreement on whether a project would stop if someone else answered the research question. The disagreement can mainly be traced to the scope of the project, given that wider questions typically have multiple sub-questions that cannot all be answered.
        - "Not very likely. They might solve a problem, but not all problems and I'm pretty sure that we will solve other problems, phrase other questions and get even beyond what other people have done." (Subject 1)
        - "Yes, actually we did right now (stop because someone else answered the question). We haven't done it in the past of us, but now we did it, […]. We just started to begin a project, and then I learned basically that somebody else had this result, and this was such an important result, central result, that all that you would have possibly have done was just some details." (Subject 2)
        - "The questions we're working on are extremely competitive so being scooped is always a problem and happens. Normally, being scooped in the research we do is not 100 percent. It's not that everything is lost, but maybe a fraction and then you try to regroup and then use the data you have and try to build the next step." (Subject 3)
        - Never really happened to me, so I would say it is one." (Subject 6)
    - Researchers would not always stop projects if the question is published in a paper. This is because sometimes results lead to new lines of research.
        - "Another reason for not continuing a project could be that a longer-term coworker is leaving the laboratory to start his or her own group and we have an agreement that this person will continue the project. This is quite common." (Subject 7)
    - Two researchers ended projects if the experiment failed or was no longer interesting.
        - "Yeah, of course we have. Our research is hypothesis driven. We are trying to imagine how things might work based on the information that we have and then we design experiments to test this. Ideally, obviously, the outcome of these experiments should be interesting either way, but isn't always like that." (Subject 7)

Evaluation

- Main evaluation strategy

- Six researchers mentioned that the main evaluation method was publication data (raw publications or citations). One researcher did not have any publications yet, and hence evaluation was mainly done through team meetings.
- Researchers disagreed on the importance of top journals or citations as a method of evaluation. Answers ranged from important, somewhat important, and not important.
  - "We try to aim for the absolute top journals and that's where we want to see our research ending up. If it would fail to do so that would be disappointing, of course." (Subject 3)
  - "Citations is perhaps the more objective criteria than simply only the ranking of a journal." (Subject 7)

Knowledge and Information Sharing

- Determinants of sharing information outside the lab
  - Five researchers mainly shared information in order to receive some sort of feedback. However, researchers pointed out that information sharing should be done with caution as you can create unnecessary competition.
    - "You want to be seen and other people to know you are there, because it makes no sense to work all by yourself and not be evaluated." (Subject 5)
    - "it's quite important to get technical feedback in how to do certain experiments or how not to do certain experiments. It's not absolutely crucial, but it's one important aspect" (Subject 3)
  - One researcher pointed out that sometimes they share in order to establish a position and disincentivize other people from joining that particular research field. Two researchers stated that this is not a good strategy because it is rarely the case.
    - "to avoid being scooped. It's a wrong strategy, but I try to not overshare in order to avoid being scooped." (Subject 5)
    - "That's something I think is stupid unless you have this single idea which makes all the difference but it's very rarely the case." (Subject 1)

Collaboration Patterns

- How common is collaboration in your field?
  - Six mentioned that collaboration is common. One researcher was not specifically asked about collaboration.
    - "I would say more than ninety-five percent of publications have offers coming from probably more than two or three labs." (Subject 3)
    - "It's happening all the time and I think most of my obligations have additional PIs on it" (Subject 6)
    - "Yeah. Quite common, I would say in perhaps 20 to 30% or so, could be more" (Subject 7)
- Determinants of collaborators
  - Three researchers mentioned that they typically collaborate to access certain outside expertise.
    - "It's indeed that we have a research question and we can answer it to some extent and either we know upfront that we will need some additional techniques or during the course of the project we find something where we say, "Now it would be interesting to look at it from a different angle and, therefore, we need some of you as a different set up and different instruments or whatever to do this"" (Subject 6)
    - "Basically to recruit expertise that we don't have" (Subject 7)

Competition

- Degree of competition
  - Five researchers believed their field was very competitive. However, they disagreed on whether competition has changed or not.
    - "It's not a five (the degree of competitiveness) because we try to talk to all our competitors to organize it in a way that we coordinate with them and try to publish back to back. We do not try to scoop another person. We would rather publish back to back with them and then everybody has a benefit of them" (Subject 3)
    - "I think maybe the competitiveness of the people, I don't know if that has changed or not, but it... So, in a way, I have the feeling that the amount, let's say the qualitative nature of competition has changed." (Subject 2) One researcher pointed out that sometime you may not know who your competitors are.
- Would competition benefit or hurt the field?
  - Researchers were unsure if more competition would hurt or benefit the field. Instead they emphasize that it might make some people work harder, which could be good or bad.
    - "I don't know, I think the level of competition is quite high enough. So, I don't know, it depends a little bit on the personalities" (Subject 2)
    - "Not sure—it may make some people work harder.
    - "I'm sure that the competition results in a faster progress. It definitely makes us faster. It makes us more focused, but of course it also makes us more stressed." (Subject 3)
    - "Too much competition would be stressful potentially and also then hindering because you need to have a certain freedom to develop your ideas and too much competition would certainly not be ... I don't think it would be beneficial." (Subject 7)

Equipment and Funding

- Hypothetical situation of receiving double funding
  - Researchers disagreed on how they would spend money if they suddenly received double the funding. Some stated that they would hire more people, others would buy more equipment or take riskier projects.
    - "It doesn't make sense to increase labor, so at some point you cannot take care of ... I'm already beyond the point where I know every day's work of the people so it just doesn't make, the efficiency of work goes down dramatically if you increase the workload even more" (Subject 1)
    - "There is always equipment you can buy." (Subject 5)
    - "So I think in principle I would, I could definitely think of some additional work to do, but I would need to hire some other people for that. And for instance, these mice studies would be nice of course to do them in house, but that would require so much money and effort that we never bothered about doing it. But they'd save it would have a double, double budget. We probably would go maybe this route, but I'm not a specialist in that at all. You need to hire people, find good people. I don't think it will double our outcome" (Subject 2)
    - "I think we would continue what we do but we would diversify. Right? It would allow us to take more risks and take projects which we think are super exciting but maybe are technically challenging or are maybe not that easy to pursue." (Subject 3)
    - "perhaps, I would be able to invest in certain technologies that we didn't have before and also then make those technologies available to others in the Institute." (Subject 7)

- Impact of access to suppliers (supply shortages)
    - The degree of flexibility towards access to suppliers was also very different depending on the researcher. Some, stated that they would have to entirely stop their project, while others would be able to make their own supplies or find a suitable substitute.
        - "Yes. Yeah, that's a good point. So I think if I would not be able to do structural biology anymore, which was kind of my, I don't know, my, my major interest then, I don't know what I would do really, I would find something I guess." (Subject 2)
        - "I mean for the optical instrument of course you cannot build the optical microscope but we're not doing it anyway, right? So, no. I would still try to keep technology to the point that we can build it ourselves if needed." (Subject 1)
        - "It would probably give us a bump but in principle there's nothing we can't work around given enough time. Probably if it turns out that this will be an impasse that will take three years to work around then it would change things. But so far it's never happened." (Subject 5)
        - "not so much maybe for instruments but biological material. For example, we require serum for tissue culture and we try to buy that in large batches so that we can do constant experiments over... Run an entire project with the same batch of serum. But of course, serum can end what we have, and then we would have to change and a different lot, we need to make sure... So, this can be quite cumbersome and very annoying. But, at the moment, almost everything is owned by Thermo Scientific. So, I don't see them going away." (Subject 3)

Ethics and Norms

- Open exchange of information is common?
    - Six researchers believe that exchanging information was common
- Researchers provide valuable feedback?
    - Researchers disagreed on the extent that other researchers provide valuable feedback. Responses ranged from 2 – 4.
- The first to come up with results is highly esteemed?
    - All researchers believe that the first one to publish takes most of the credit.
- Researchers often use ideas and results from others without acknowledgment?
    - Researchers mostly agreed that this was a problem, but it was not a major concern. Most of them ranked it as 3 out of 5.
- Researchers often falsify data?
    - Researches agreed that this is not a major concern.
- Researchers often take false credit?
    - Researchers disagreed on the extent that people in the field take false credit. Half of the researchers believed that this was probably the biggest problem, while the other two did not believe it was a problem at all.
        - "This is probably a much bigger problem, I would say, than the data falsification. I think that there's something, one probably needs to look a little bit more into it. I think also, I don't, would undersign the word often, but it's something that that probably happens regularly whether it's the majority or minority, I wouldn't say, so." (Subject 2)
- Two researchers mentioned that the nature of ethics has changed due to advances in technology/publication quality.
    - "There is so much more statistics in data presentation and also the documentation of the data is more thorough than in recent years and, also, journals check more on the integrity of the data in submit." (Subject 6)

Geosciences

Sample

- 6 researchers
  - 2 Associate Professors, tenured
  - 1 Professor, tenured
  - 3 Research Scientists, non-tenured
- Male: 6
- Female: 1
- Tenure track: 3
- Technical Staff: 1
- Research Staff: 2
- PhD Student: 1
- Major areas of interest: Geophysics, geochronology, climatology

Main Similarities

- Preference to work at the off-campus research facility (if an option)
- Don't usually see themselves as working in a lab
- No lab managers; desire to maintain control over their projects and keep a flat hierarchy, even with the opportunity to expand
- Understanding that the academic incentive system biases science; seemingly common to think that they would behave differently if there weren't pressures on them
- Priority on publications and developing new knowledge
- Project plans are not developed based on a student's interest, the student is brought in to the project (but hopefully onto one that matches their interests)
- Commercial potential perceived as unimportant
- Protective of physical samples
- Social media, conferences good for sharing and promoting work
- Students generally learn ethics through osmosis
- Space may be valued for storing equipment, promoting interaction between people, or for providing a private space away from distractions

Main Differences

- Variety of interests and research methods (physical models, computational models, some do field work)
- Amount of work done with students varies (some specifically avoid working with students while others take on advising roles despite not having that responsibility)
- Variety of funding models (industry associations, corporate funds, government grants)
- Given that there is a separate research facility loosely associated with the geoscience dept., many PIs are non-tenure track

Research Goals and Organization

- Research questions have changed over time in order to advance careers, but not necessarily in a way tied to tenure—more in a way to establish a coherent reputation. Establishing themselves as an expert in an area and pursuing research questions of interest is important. Having too diverse a portfolio can negatively impact tenure but might be a goal as careers advance and funding is available. Approaches to research questions change over time with improvements in technology, available data, and statistics.

- Lab space
  - Each has their own office and some additional space for storing equipment or for computers that students work on. Collaborators are often non-co-located (especially for the geochronologist who travels to collect samples). Groups seem to range from 5-12, mostly made up of students and postdocs. PIs often have different collaborators for different projects.
  - Some split their time between the university's main campus and another university affiliated research organization off the main campus. Some research groups have "areas" at the off-campus site where collaborators sit near one another; this is viewed as better and establishes a more coherent group. The tech support interviewee specifically avoids sitting with a particular group to establish himself as a free agent.
  - Several interviewees, including the student, noted that they prefer to go to the off-campus research facility because it is quieter and they can get more work done there, away from other students and the distractions of campus. Other factors also impacted people's opinions on space—what equipment do they need to use, where do they live, etc.
- Lab manager
  - Lab managers are uncommon, there is some staff support through the university. The PI generally directs the flow of research, but expect students to be relatively autonomous. Early students do what their advisor tells them to, though this doesn't seem to involve any admin work.
  - Non-tenure track researchers have much more admin support for obtaining funding, either to help them write grants or to help chase down sponsor's money
- Determinates of lab size
  - Funding and the nature of the research project are agreed to be extremely important by most. One believes that funding isn't important because if they really want to pursue a project they believe they can make it happen. Another stressed the importance of space because an open, well designed workspace enables better collaboration with students. However, some of the faculty don't work with a lot of students so this isn't always a concern.
  - The funding model affects how the lab works as an organization as well. Some have extra administrative support specifically because they work on soft money and need assistance getting grants or ensuring sponsors pay their dues. In one lab where they have industry sponsors who provide much of their budget, they have to consider what they will present at their annual meeting and therefore they hold bi-weekly meetings to maintain familiarity within the group of one another's work (as they do this work solo, usually) and ensure that they're working on projects that will have deliverables in time for the annual meeting. Furthermore, when they work on soft money they have to have different funding sources—NSF won't cover their salary like they need it to so they have to seek money elsewhere.

- Lab goals
  - Publications are very important but are not necessarily the same as reputation—this comes from the quality of work. Pubs are more important for students and early career researchers so that they can establish their careers. Creating new knowledge is recognized as the goal of a tenure track professor and everyone but the technical staff member though it was extremely important to research groups. Interestingly, the technical staff member thought creating new knowledge is somewhat important to research groups.
  - Technical and research staff report success as being the accomplishment of a task set out for them (regardless of the data/results).

    - "Playing the game" came up several times, but not necessarily as part of this question. Several faculty commented on how they must get publications in order to "play the game" and advance their career. This is sometimes at odds with their ideas of good research practice or good uses of time, but they understand its necessity.
- Lab budget
    - Salary and students are the biggest proportion of the budget. Depending on the research area, other funds are directed differently. Computational work requires few materials or outsourcing of analysis, but researchers who work with physical samples have to pay others for analyses and must travel to collect their samples. Some have one or two postdocs, some don't have any. If they have to buy equipment, that could be very expensive, but that is rare as they all seem to have the equipment they need.

Research Topics

- People generally responded not to how important the factors were to actually engaging the project but instead they answered how likely they thought the project was to succeed, how challenging they think the problem was, etc. However, this was not consistent and it's hard to compare responses.
- Commercial potential was consistently rated low, even for those whose work was part of an industry association. Industry associations (IAs) are like research communes—oil and gas industry partners pay a fee to hear about and have some rights to research findings.
- It was common to think solving a real world or a challenging problem were important. Dissertation topics seemed to be a happy byproduct of the research.
- Some viewed funding as extremely important (esp. if on soft money) but others viewed it as not important because they already had it.

Evaluation

- For tenure track faculty, all agreed that publications were the measure of success. It was common to view contributing knowledge as the most important goal. The technical support staff person noted that he is personally satisfied when he has exercised his programming skills and demonstrated value to his organization. Another non-tenure track researcher described success as happening after he has created the physical model he's been working on—the data doesn't matter, just the model's successful creation and capturing it in images.
- For the IA, they note that publications are important to them but that they also have to ensure that publishing with the data is okay with their sponsors.
- Some noted that the quality of the journal was important. Some emphasized that this is what the university expects but that they personally care more about contributing to their field's ongoing discussion of a topic. Generally this was seen as especially important for students and postdocs who are early in their career. This is also seen as part of "playing the game;" regardless of researchers' personal perspective on how journal ranking or publication numbers should matter, they know that it does matter in their evaluations and therefore try to do well along this metric.
- Dropping a project seemed uncommon. Instead, sometimes they are reoriented. Key personnel leaving might end a project.
- Evaluation methods are typical of field. However, some seemed to think that their personal values conflicted with norms. While they might say that they understand publications are important, they personally value good/interesting work more than racking up publications.

Competition

- Differing opinions on how competitive it is. Generally recognized that funding is competitive.
- Several noted that there are subfield differences in how competitive people are. One noted that their field has a history of bad actors who are highly competitive and disparaging of others' research. He believes this has propagated and created a new generation of "nasty people.
- Competition for jobs has increased because there are more people.
- Some competition is good for academic rigor.
- Funding was generally seen as a driver of competition. One respondent noted that people who get money from companies or IAs behave differently and have different levels of competition because the expectations for what they report and share are different than for people who get money from government funders. One interviewee suggested that academics' egos also lead to competition.
- For some, who get funding from the oil and gas industry, the price of oil can affect their funding opportunities, and that can possibly drive competition.

Knowledge and Information Sharing

- Some have weekly meetings. Most meet individually with students. Informal discussion is common.
- Email, Google Hangouts, Skype, are commonly used.
- Some documentation and training for students is formalized, but generally students learn through osmosis—especially during the paper writing process. New employees at the off-campus research org might undergo training, but this leaves something to be desired.
- Often, the meetings are to keep everyone appraised of what people are doing individually, rather than to do collaborative work.
- Funding for geophysicists might come from IAs, companies, or the state—these organizations will commission work and this means that the expectations for deliverables differ widely. If the funds come from an IA or a company, the data and results will get shared exclusively with the stakeholders, by sending a hard drive or thumb drive or by posting them to a secure online portal. If funds come from the state, data and results might go up on the web for the public to see. One researcher shares software code openly via his website.
- Drafts are shared with co-authors but feedback quality is variable. There was generally little fear of being scooped.
- Journals publications and conferences were consistently seen as important for sharing results and for students to network and build their reputation. Conferences lead to new collaborations and informal communication. Preprints and conference proceedings differed in importance, presumably due to different research areas.
- A couple of people mentioned social media as a way to share work.
- How does competition shape information sharing?
    - Inconsistent responses; some speculation that working in a more competitive space might influence how secretive they are.
- How does commercial orientation of your topic shape sharing?
    - None viewed themselves as having a commercial orientation (even those who do work directly for companies). Those who do commissioned work don't share results with outside parties. Proprietary datasets they obtain from IAs or others are not shared openly.

Ethics and Norms

- Rate how strongly you agree or disagree with the following statements (scale of 1-5 with 1 = strongly disagree and 5 = strongly agree). (not all Ps had time for this question)

Norm	Average
Open exchange of info	**3.4**
Providing valuable feedback	**3.5**
First with results is esteemed	**3.5**
Using ideas/results without acknowledgment	**2.5**
Falsifying data	**1.2**
Taking false credit	**2.4**

- Few thought negative behaviors were common but some though it more likely to be perpetrated by students who need to learn appropriate citation/crediting behaviors. One person thinks faculty often take credit for students' work.
- Differing opinions over the quality of feedback (ranging from 2-5, one person saying it used to be bad but is improving) and how esteemed first-results-getters are (ranging 2-5).
- Some agreed that, were the negative behaviors to occur more often, they could have a significant negative impact.
- Inconsistent responses about changes to ethics and norms. Some brought up more movement toward being open, transparent, and inclusive, and that there is more discussion about poor behavior.
- Advisors are responsible for educating their students; often they learn through osmosis.

Collaborative Patterns

- Most said it was common to collaborate with outsiders, but not all view themselves as having a lab to begin with. Research groups might form around specific projects, but are not necessarily comprised of a regular group of co-authors. Participants seemed to determine whether or not they had a lab based on if they had other faculty that they usually collaborated with. Just having students did not make their work a lab. Interestingly, even if the group had the word "lab" in its name, members didn't necessarily perceive it as a lab.
- Adding different skills or subject area expertise was generally a motivator for collaborating and a means of deciding who to work with. One noted that he values personality more than skillset, however.

Funding

If funding were doubled? (number of responses in parentheses)

- Common to want to maintain control over the projects and not delegate too much, which means that they are constrained by their own expertise and time. One participant notes that their answers would be different depending on the period of the doubled funding (5, 10, 20 years) because that impacts their capability to hire students.

1. Would you continue your current research both in terms of direction and level?
    - No (0)
    - Yes (4): would work faster, but in the same area with more projects
2. What changes would you make?
    - Labor (4): more people (students/postdocs/admin) for more creativity and speed

- Space (1):
- Equipment (1): equipment might reduce need to travel, more money for equipment would increase its importance to the lab "…that's how things improve in geology is the technology improves. That's how breakthroughs are made, so getting better technology available is going to be more important than getting more rocks. We already have a lot of rocks."

3. Would you introduce a new research stream?
    - No (3): new people might shift things some, but a whole new direction takes whole new expertise "I think we've got plenty now"
    - Yes (1): already has the idea and would want to diversify
4. Would you be able to obtain necessary research space?
    - No (1): would want basically an addition to a building
    - Yes (3): others previously expressed that they have sufficient space (interestingly, none talked about wanting to only work in one place, even though many have offices in two locations in town)
5. Would your collaborative patterns change?
    - No (3):
    - Yes (1): because more students/postdocs
6. Would the organization of your research group change (e.g., would you hire additional lab/research directors under your direction)?
    - No (0):
    - Yes (3): might hire admin for budget stuff or equipment managing, still keep control over most projects though
7. Would you consider using some or all of the additional monies to make a grant to another research group (that is, would some of the funds be under the direction of a different research group)?
    - No (2): "No way"/ "Hell no"/ "That's well beyond my role"
    - Yes (2): maybe, if they had a ton of money to give away or if they had personally reached maximum group size/efficacy

Mechanical Engineering

Sample:
- 7 professors, top US public research university

Main Similarities
- Constraints
  - Funding: drives choice of research question, space allocation, number of students they can hire
  - Space: reason for collaborating, often shared with other faculty
  - Administrative: IRB and grant writing slows them down, takes up much time, prohibits students from even starting certain projects
  - Information sharing is NOT practiced for fear of being scooped
  - Overall competitive pressure high; mainly for funding
- Number of projects: typically 5-8
- Max lab size: 13-20 people, 300-1000 square feet
  - Lab manager viewed as not important at 20 or fewer people; no mention of management training
  - Postdocs:
    - experts or even a "tool", but not viewed as students to be trained
    - rarely hire postdocs
- Research budget in a year
  - Equipment (purchase, rental, and or maintenance) – 0% - 10%
  - Materials –0% - 50%
  - Students – 35% - 90%
  - Postdocs – 0% - 10%
- Research topics
  - Typically have multiple topics they focus on that intersect with distinct subfields (e.g., one person: electrothermal, electromechanical, photoactive materials)
  - Collaborate or hire a postdoc to get the necessary expertise to do so
  - Seem predominately "problem focused"
    - "We look at a problem that may exist and we try to come up with a solution to that problem, as opposed to being very disciplined focused, where you work in a discipline and you try to create new tools for that specific discipline. We're technology focused" (Subject 5)
- Research method
  - Experiments
  - Simulation
- Students
  - Stress development
  - Where their students get jobs (academia, industry or national labs) does not seem to be a priority. (There was one case where the professor stated preference for academia)
    - "Whatever they want, if they say, "Hey, I want to go work at Boeing." I say, "Okay, I probably need to get you an internship at Boeing halfway through." It doesn't matter to me. If they want to be a professor, I have to make sure they have teaching experience while they're here. Now, it's just a matter of talking to them, see what they're interested in, and know them from there." (Subject 5)
    - "So if most of 'em said, "I wanna go to government research labs." Fine. If they want to go into industry, that's fine. I'm not gonna change the kind of research aspirations I have based on where they wanna go. They're gonna learn the

important lesson that everyone has to learn, is that when you're working with somebody at a university like me, you're gonna have intellectual inquiry as sort of the guiding principle. And you can diversify that and take that into any direction you want with guidance and support, but that's the name of the game there, right?" (Subject 1)

- Ethics
  - Concerned with researchers from more "underdeveloped" countries who may not have the same set of norms (don't cite, reinvent the wheel…).
  - Concerned with how to deal with open accessibility online (e.g., what you can even expose on facebook).
  - Ethics and norms are passed on through "leading by example", can't necessarily be taught
- Funding
  - Situation double funding:
    - Would you refuse a doubled level of funding and prefer to stay your current size?
      - NO (7)
    - What would change?
      - Labor (7): get a postdoc in order to probe into new topics (2), double (2), PhDs (1)

Main Differences

- Constraints
  - Postdocs: issues with citizenship, so some say they could get a postdoc if they wanted (but they don't want any), others say they couldn't get any (even if they wanted to have one)
  - Students: some oversupply (especially aerospace), some undersupply of good applications (depends on the program ranking)
- Collaborative patterns
  - Many collaborate internally (within university), though some specifically state they try to avoid internal collaboration
  - Mainly work in on campus lab but some need to test in remote places/designated testing areas given the nature of the research (e.g., aerospace flight testing facilities, Zoo for animal observations)
- Commercialization
  - Some think academics should not commercialize, others state patenting and startups are not for them, and others are visibly proud of being active patentees/having startups
- Knowledge and information sharing
  - One interviewee mentioned news outlets like the New York Times as an important way to disseminate knowledge, others stressed making devices people can actually use as an important way to share knowledge
- Funding
  - Some get a substantial amount of funding from industry; the outlier was receiving 70% of their funding from industry
  - Some would never take funding from large corporate firms, others do
- If funding were doubled? (number of responses in parentheses)
  - Would you continue your current research both in terms of direction and level?
    - NO (4): would speed things up, double it up, take on more risks
    - YES (3): direction same, but increase level, more experiments
  - What would change?
    - Labor (7): get a postdoc in order to probe into new topics (2), double (2), PhDs (1)

    - Space (1): double
    - Capital (3): equipment and computer capabilities
    - Other: organize workshops and bring people from different areas together, no need to increase equipment—could increase utilization
  - Would you introduce a new research stream?
    - NO (4)
    - YES (3)
  - Would you be able to obtain necessary research space?
    - NO (5), reasons: super dense as it is already, problematic
    - YES (2), reasons: if you bring in money the university is more willing to talk about it
  - Would your collaborative patterns change?
    - NO (4)
    - YES (3), reasons: more in-house and less reliance on collaboration with people at different labs, more
  - Would the organization of your research group change (e.g., would you hire additional lab/research directors under your direction)?
    - YES (3), changes: More students, research engineer to manage the students
    - NO (4): "For me, doubling the money, doubling the people is still not necessary for a lab manager. I think you have to have more than 20 people to have lab manager." (Subject 3)

Molecular Biology

Sample

- 2 Assistant Professors
- 3 Associate Professors
- 4 Professors

Main Similarities

- Research goals and organization
  - Most (8/9) participants have an active lab constituted of at least 1 PhD student, 0-2 postdoctoral students.
  - 8/9 have technician, who acts as lab manager and a "safety officer" and meeting organizer.
  - The architectural and physical arrangement of laboratory: offices near bench; space organization coincides with disciplinary classification, e.g. evolution and ecology on first floor, molecular and cell biology on second.
  - Lack of formal management training for PI and technician is a shared characteristic of all interviewees, but is not perceived to have a negative impact on the labs.
- Research topics and questions
  - All devote career to same topic, general foundational questions, but branch out with methodologies, organisms, and sub-topics.
    - "With every observation we make, there are more questions that come out of it. That's why then research programs can last forever. I can be asking this one question and basically for the rest of my professional career be studying this one question. How one gene affects cognition and behavior. So that's the big picture." (Subject 4)
  - The research areas fall broadly under molecular and cell biology, but every scientist has one or more topic area(s) that are the "bread and butter," the major field that gets funded and "keeps the lights on." Bread and butter is usually an applied or basic field that has a level of immediacy in terms of application. E.g., Biofilm → antibiotic resistance. But there are exceptions to this, based on previous success in an area ("track record" in). It is common to have one risky topic area (and less so >1). These are sustained because they are the "passion" and "real area of interest" that may be less likely to get funding.
  - Sub-fields in molecular biology can be classified into basic science and applied sub-fields, and in this sample include plant ecology and evolution; neurobiology; antibiotic discovery; multi lineage leukemia (MLL); female fertility; neurobiological disorders; reproductive evolution; genomics of sex differences in fish; agriculture; intellectual disability.
- Methods: increased reliance on computational tools, but using traditional inscription devices such as assays and reagents to conduct experiments in the lab.
- Evaluation
  - Citations to publications are not the primary indicator of impact or research quality.
  - The "solidness" of the research experiment and its success at answering a well-defined question are the criterion for evaluation.
  - A multi-disciplinary view on a research project is judged by the reviewers and the PIs as more comprehensive and higher-quality work.
- Competition
  - Molecular Bio has become increasingly competitive in the last 25 years.
  - Competition is a double-edged sword that does not contribute to progress in the field when 10% of grants are funded from 2 major funding agencies.

    - Competition for funding can and has shut down labs “doing good science” (Subject 7, Subject 9). Competition for students can pull “the good ones” toward well-known institutions.
    - A gap year in funding can stunt and slow projects from reaching completion.
    - Prefer the Canadian system, of small grants and guaranteed “keep the lights on” funding (Subject 3).
    - Commercialization is not a goal or driver of research: it is a subsidiary perk of biomedical applications and can better the chances of securing research grants.
- Knowledge and information sharing
    - Trend toward increasing use of and contribution to the preprint server “bioarxiv”. However, competition and risk of “getting scooped” submission timing carefully, strategically planned.
    - Participants submit research data to an open repository (GenBank, GEO Omnibus). Incentive structure varies by grant.
    - Do not have time to review others’ papers.
    - Use RSS feeds and google scholar browsing to discover research. Attend conferences, brown bags, seminars, and informal conversations with colleagues and students such as lunches and social events.
- Ethics and norms
    - Students learn from PIs.
    - Students “get burned” when research is scooped or they witness personality conflicts around information sharing and collaboration at conferences.
    - Weekly lab meetings with research group and daily meetings with PIs.
    - Students submit nucleic acid sequence data to large data repositories; gain technical knowledge around information sharing, but also the policies and procedural norms and culture of data and information sharing.
    - Conferences with professional development workshops.
    - If student “selectively analyzes” results, the PI reprimands the student for misconduct and attempts to instruct and understand why the student falsifies. The motivation (P9) of the student is “everyone else is doing it; we are at an unfair disadvantage if we do not.”
- Collaboration
    - All participants report the highly, increasingly competitive nature of molecular biology this is a change from how it was in the ‘90s. Not contributing to progress of field; because 10% NSF grating rate = good labs die and good science cannot get funded.
    - All participants are highly collaborative; across and within discipline.
    - Team size and correspondingly co-authorship are rarely solo-authored.
    - Common collaboration partnerships are: Molecular and Cell Biology with physics, chemistry, and neurobiology.
    - Many levels of collaboration according to the expertise need: have or need desirable and expensive data, have or need technical skills or technology, have or need reagents, have or need knowledge in a technique or method.
- Funding
    - All would double their funding: none of the participants would refuse the money.
    - Would not necessarily become more efficient with doubled funding: calculated returns in consideration of riskiness, efficiency, and PI-time allocation constraints (Subject 3).

Main Differences

- The organisms and lab materials used for a research topic and experiment (e.g., mouse versus fly versus yeast) are associated with an create differences in resource allocation, research group roles and responsibilities and space requirements, among other things.

- The scientists in molecular biology rely on computational tools to varying degrees (e.g., identify as a data scientist; identify as an experimentalist; know very little mathematics and physics; everyday they write scripts in Kobol, python, and C).
- Why they seek collaborators and who the collaboration partners are
    - While all collaborate because either they provide expertise or need outside expertise, the details of the expertise vary widely: e.g., for the population of Saudi Arabia which has recessive gene expression, versus Asking a NL researcher for a reagent (material), requiring technology, or the "psychological side" of genetic disorders.
- Co-advising and sharing labs: 1/3rd of the interviewees co-advise PhD students and 1/4th share a lab with another PI.
- Different preferences for style of managing students
    - Encourage and prefer undergraduates
    - Do not accept undergraduates and do not prefer.
- Sources of funding and allocation of resources
    - While most participants agree that postdocs and materials are most expensive, not all labs have postdocs nor do they need sequencing technology.
- Recruitment methods of students
    - programs are structured differently between private and state universities.
- The primary funding sources in molecular biology are national foundations such as the NSF and NIH. However, these are competitive so the PIs supplement their grant writing with foundations such as Alzheimer's Foundation
- How students are funded
    - Private institution = Teaching Assistantship
    - Public/state must use grant funds for PhD student stipends and postdocs
- Constraints experienced by molecular biology interviewees
    - Competitive Funding: shuts down labs; stunts and slows projects from reaching completion (Subject 9). Grants are allocated every 3 years, on average: this means the PIs are constantly writing grants.
    - Inequality in review process, name –recognition is king.
- Cycles of lab turnover
    - Students exit lab, take data, and leave behind half-finished papers.
- Ethics of information sharing
    - Trust and suspicion in data: Transparency in reporting findings.
    - Data falsification and "wishful" interpretation of data undermines trust in Open Access (OA) publications.
    - Weak incentives no incentives for data sharing. The funding source structures data-sharing incentives.
    - Journal publishing culture that selects "flashy findings" e.g., Science; and data inflation and/or partial-reporting in OA e.g. PLoS.
    - Getting scooped as a result of poster session sharing; PI and students fail to get adequate recognition from scholars in same field using the lab's findings
- Failing to get early career momentum because of "series of unfortunate events" causes debilitating set-backs; cannot recover from one bad year of funding because of competition for grants.