

## Criteria for Authorship\*

The key to fair allocation of authorship and equitable ordering is to have criteria that are known to all and that all can discuss. In my lab, a substantial creative contribution in one or more of the following phases of research is sufficient to warrant inclusion as an author of the paper reporting the experiment(s). A lesser creative contribution warrants an acknowledgement in the footnote of the paper. I determine whether someone deserves either of these credits, and determine the ordering of authors, by counting up each person's contribution to each phase. As noted below, I assign a larger weight to the first and last phases, and to any other phase that requires special expertise or creativity (e.g., data analysis, in some cases).

However, I do not make this decision in a vacuum. Each contributor sends his or her own assessment of their contribution after the project is relatively complete but \*before\* the paper is written.

In my lab, we consider 6 criteria, and weight them as explained below. Often the "points" at each stage are divided among several people. If a person "contributes creatively" at any of these phases, that is enough to qualify him or her for an acknowledgment or as a co-author, depending on the magnitude of the contribution. Moreover, the "replaceability criterion" leads us to ask whether one person's contributions could just as easily have been made by others; if not (i.e., if the person would have been difficult to replace), that contribution is weighted more highly. However, it is important to note that each project is unique, and while these criteria in combination with their addendum will work for the majority of the projects in our lab, there will be exceptions. When these arise, they should be openly discussed.

Ideally, the point totals of each phase should be agreed upon in advance. However, this is clearly not possible, as it is not possible to predict the path a project might take. The following are "default" point values, with a total of 1000. The total points for each phase is divided among authors in proportion to their contribution in that phase of the project. In my lab, if someone contributed more than 0 but less than 10% of the total number of points, they are acknowledged in the footnote. If they contributed at least 10%, they are an author, and the ordering of authorship is determined by the relative number of points.

**1. The idea (250 points):** Without the idea, nothing else happens. If the idea grew out of a discussion, all who contributed get "credit"--but perhaps not equally so, if one or more people were primarily responsible for the insights leading to the best way to pose the question to be answered by the research and the logic of the design.

**2. The design (100 points):** The details of the experiment design include the exact experiments which should be performed along with appropriate control experiments to demonstrate to concept. Without good experimental/theoretical design, a project is not complete, so this is a critical step.

**3. The implementation (100 points):** Someone must implement the design into an actual experiment which could require ordering materials, designing instrumentation, developing software, etc. Depending on the research project, this could be boilerplate (a variation on well-developed method using available materials), and this step may be given much less weight. Typically, the person doing the implementation is supervised closely, so some of the points may go to the supervisor.

**4. Conducting the experiment (100 points):** This is a critical aspect. Authorship is awarded only to those who contribute substantially and creatively to a project; if someone is simply following instructions, then this is worthy of an acknowledgment, but not authorship. On the other hand, if they are "scientifically engaged" in the project and make constructive suggestions for how to improve the experiment, this qualifies them to be included as an author. Specifically, if one notices problems in the method or procedure, and makes constructive suggestions about how to repair them, observes interesting hints about what's really going on in the debriefings, and so on, this counts as a substantial creative contribution at this stage.

In many projects, experiments could be multi-faceted. For example, the experiments could involve both material analysis and optical device testing. If two students contribute equally (one student to each aspect), then the lead author will be determined by the other criteria.

**5. Data analysis (200 points):** Simply plotting and fitting the data using Origin is not enough to earn authorship at this phase. However, devising some new way to look at the data, developing an underlying theoretical model to explain the data, or otherwise contributing a novel insight into the best way to reveal the underlying patterns in the data, may be sufficient. Particularly labor-intensive or creative data analysis, such as FEM modeling, can earn the full number of points. Depending on the project, the maximum of 200 points may or may not be allocated.

**6. Writing (250 points):** Nothing happens if the results are not reported. Writing is usually shared by several people. Credit is allocated primarily to the one who shapes the conceptual content, although a good and insightful literature review also counts heavily. If someone writes a first draft that is not used at all, this does not contribute towards points: good intentions are not enough; the question is who has contributed how much to the final product. Similarly, the sheer amount of time one has spent on the project is not relevant; competent people who work more efficiently should not be penalized.

\*Modified from the guidelines established by Prof. Stephen M. Kosslyn, Harvard University

## Addendums

**Addendum 1: Fabrication of devices.** Many of the students in the group are focused on designing and fabricating new types of optical devices or making new materials which can be used to fabricate new optical devices. However, other students will use devices to perform biodetection experiments. One question which is often raised is: "Should the person who made my devices be a co-author?"

The most straightforward scenario is if the student fabricating the device contributed in some creative way to the successful completion of the project. This is most likely to happen if one student was making a new material and the second student was making the devices and had to modify the fabrication process in order for it to be compatible with the new material. In this case, the student fabricating the devices will most likely be a co-author.

The less straightforward case is when a student is fabricating devices for other students performing biodetection experiments. In this case, the student doing the fabrication does not contribute creatively, and therefore, would most likely not merit a co-authorship on the paper, but could merit an acknowledgement. For this reason, one of the lab duties is "fabrication", and the student(s) who are responsible for fabricating devices are not assigned to other time-consuming tasks like resonator set-up maintenance.

**Addendum 2: Surface Chemistry.** Many of the students in the group perform biodetection experiments, and we are developing (and have developed) several new types of surface chemistries. One question which is often raised is: "At what point do I stop including the person who developed the surface chemistry as a co-author?" Theoretically, this is a similar question to "Should Deniz be a co-author because we are using the toroid?" Clearly, the answer to the second question is no. However, there seems to be a lot of confusion about the answer to the first, due to the wide variety of projects in the group.

If the student can simply show you how to implement the surface chemistry on your device, then they are not contributing creatively. Therefore, they do not merit a co-authorship, but could merit an acknowledgement. However, if they have to modify their protocols for your device, then they are contributing creatively and could merit a co-authorship depending on their contributions to other aspects of the project.