# Six Degrees of Nobelity

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## PURPOSE

To study the scientific network of Paul C. Lauterbur and Sir Peter Mansfield, winners of the 2003 Nobel Prize in Medicine.

## INTRODUCTION

Social networks describe collections of people and their relationships to one another. Previously, Newman studied the collaborative network of scientists through the analysis of scientific publications [1].

In 2003, the Nobel Prize in Medicine was award to Paul C. Lauterbur and Sir Peter Mansfield for their contribution to the field of magnetic resonance (MR) imaging. In this poster, we present an analysis of the scientific network surrounding these two pioneers.

We quantified their impact on today's MR imaging community by studying the relationships between co-authors on scientific publications in the field of medical MRI.

## METHODS

Results are based on the analysis of journal articles indexed in the PubMed database. PubMed is a service of the National Library of Medicine and includes over 15 million citations for biomedical articles dating back to the 1950's [2].

A non-author-specific search was executed to obtain the set of all papers related to magnetic resonance imaging. The PubMed query was:

```
"magnetic resonance imaging"[MeSH Terms]
OR
(
  "magnetic resonance spectroscopy"[MeSH Terms]
  AND
  "diagnostic imaging"[MeSH Terms]
)
OR
"mri"[TIAB]
OR
"magnetic resonance imaging"[TIAB]
OR
"zeugmatography"[TIAB]
```

where "MeSH" stands for Medical Subject Heading, and "TIAB" is a qualifier for words in the Title and Abstract.

We adopted the definition of Newman [1], in which, two scientists are considered to be connected if they have co-authored a paper. Using terminology from graph theory, we describe our network in terms of vertices and edges. A vertex, or node, represents one person. An edge connects two vertices and indicates that the two scientists have co-authored a paper (Figure 1).

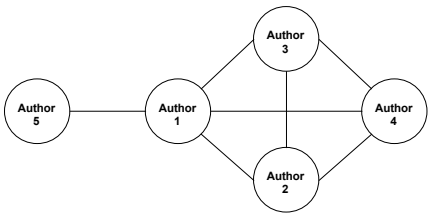


**Figure 1** A sample network of five authors. Each author is represented by a vertex in this graph. Edges indicate that two authors have co-authored a paper. In this example, Authors 1 through 4 co-authored a paper with one another. In addition, Author 5 co-authored a paper with Author 1, but not with Authors 2, 3 or 4.

**Degree of Separation**

The connectivity of a network can be analyzed in terms of degrees of separation. For the example of Figure 1, Author 1 is separated by one degree from each of the other authors. This means that Author 1 has co-authored a paper with each of the other authors.

However, Author 4 and Author 5 are not directly connected, but have each co-authored a paper with Author 1. We say that Author 4 and Author 5 have two degrees of separation.

The degree of separation between two authors equals the minimum number of edges that have to be traversed in order to connect the pair of vertices that represent the authors.

**Implementation**

The results of the PubMed query were initially formatted as a standard ASCII text file. A PERL script was written to parse the results and extract the author list for each citation. Each author was then added to a mySQL database Author table that was configured to avoid duplicate entries. A separate Connections table was used to store the set of connections between any two entries in the Author table.

## RESULTS

On November 15, 2003, the non-author-specific PubMed query returned 136,474 citations, representing the work of 202,154 scientists. Analysis of the raw citations indicated that there was a mean of 4.6 authors per paper. Each author published an average of 3.1 papers.

Paul Lauterbur co-authored papers with 61 colleagues. Peter Mansfield had 80 direct collaborators. There were 1291 scientists who co-authored papers with Lauterbur and Mansfield's primary collaborators (2nd degree of separation).

Table 1 shows the population size for each degree of separation from Lauterbur and Mansfield.

The total number of individuals in Lauterbur and Mansfield's network (181,702) amounts to 89.9% of the MR community we studied. Figure 2 shows that while some scientists have collaborated with more than 100 individuals, it is most likely that a given author has only 4 or 5 collaborators.

## DISCUSSION

The results show that Paul Lauterbur and Peter Mansfield have had an indirect influence on a huge proportion of scientists in the MRI community. We found that 99% of Lauterbur and Mansfield's collaborative network was within the anecdotal six degrees of separation from the Nobel winners [2].

The dwindling number of collaborators at higher degrees of separation may have two explanations. Authors who are more distant from Lauterbur and Mansfield may be new to the field, and have had less time to interact with the network. At the same time, since the MR field is young, and Lauterbur and Mansfield are still contributing to the field, they continue to populate the closest tiers of their network.

Since this work used only the PubMed database, our results do not fully represent the entire MR community. Access to databases with other focuses, such as engineering or physics, should provide a more complete picture of the community.

In addition, ambiguity in author names could generate artifacts in our results. Possible scenarios include an author who is indexed multiple times (i.e. with and without middle initials, misspelling), or multiple authors who are indexed once (i.e. different authors who share the same name).

| Degree of Separation | Number of Authors | Percent of Total MRI Authors |
|---|---|---|
| 0 | 2 | 0.001 |
| 1 | 141 | 0.07 |
| 2 | 2,297 | 1.1 |
| 3 | 30,668 | 15.2 |
| 4 | 94,526 | 46.8 |
| 5 | 43,119 | 21.3 |
| 6 | 8,762 | 4.3 |
| 7 | 1,680 | 0.8 |
| 8 | 353 | 0.2 |
| 9 | 126 | 0.06 |
| 10 | 27 | 0.01 |
| 11 | 1 | 0.0005 |
| **Total** | **181,702** | **89.9%** |

**Table 1** The size and population at each degree of separation from Lauterbur and Mansfield.

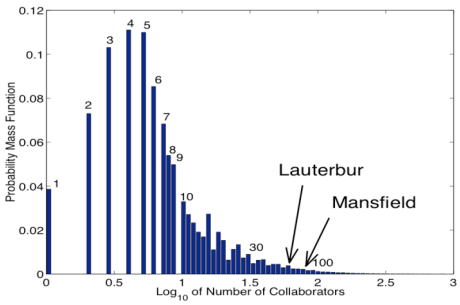


**Figure 2** Probability Mass Function: number of collaborators for authors in the field of MRI. This histogram gives the probability that a scientist has exactly some number of co-authors (primary collaborators).

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