

Mathematical ingenuity traced in the academic genealogy of mathematicians

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- ▶ In German the Ph.D. supervisor is called 'Doktorvater'=the doctoral father
 - genealogical aspect of doctoral graduation
- ▶ The **genealogical network** may contain information on the fruitfulness of mathematical concepts or 'mathematical ingenuity'.
 - ▶ A good mathematician can find and solve open mathematical problems
 - ▶ A good mathematical doctoral father/mother is able to transfer open problems and solution concepts to students

<http://genealogy.math.ndsu.nodak.edu>

Mathematics Genealogy Project

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13665 records as of 5 October 2009
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North Dakota State University
P. O. Box 6050
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Mathematics Genealogy Project

Carl Friedrich Gauß

[Biography MathSciNet](#)

Ph.D. Universität Helmstedt 1799

Dissertation: *Demonstratio nova theorematum omnium functionum algebraicarum rationalium integram unius variabilis in factores reales primi vel secundi gradus resolvi posse*

Advisor: [Johann Friedrich Pfaff](#)

Student(s):
Click [here](#) to see the students listed in chronological order.

Name	School	Year	Descendants
Friedrich Bessel	Georg-August-Universität Göttingen	1810	18333
J. M. Richard Dedekind	Georg-August-Universität Göttingen	1852	
Johann Encke	Universität Berlin	1844	5235
Christian Gerling	Georg-August-Universität Göttingen	1812	34923
Sophie Germain	Georg-August-Universität Göttingen	1830	
Christoph Gudermann	Georg-August-Universität Göttingen	1841	15498
Johann Listing	Georg-August-Universität Göttingen	1834	
Georg Riemann	Georg-August-Universität Göttingen	1851	

According to our current on-line database, Carl Gauß has [8 students](#) and 47740 [descendants](#).
We welcome any additional information.

If you have additional information or corrections regarding this mathematician, please use the [update form](#). To submit students of this mathematician, please use the [new data form](#).

¹Acknowledgements go to Markus Geipel for crawling the data.

Advisor direction, starting with me

26 = Jacob Bernoulli 1684, 3 students

19 = Leonhard Euler 1726, 2 students

9 = Carl Friedrich Gauß 1799, 8 students

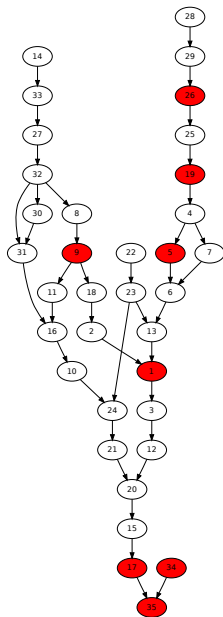
5 = Simeon Denis Poisson 1785, 3 students

1 = C. Felix Klein 1868, 58 students

17 = Ulrich Krause 1967, 5 students

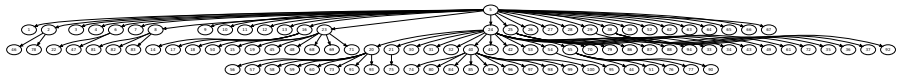
34 = Rainer Hegselmann, Philosoher

35 = Jan Lorenz 2007



- ▶ Only one advisor has long pedigree
- ▶ 'Incestous' production observable

Student direction from my grandfather



- ▶ Spreads very fast: If not lots of siblings, then lots of cousins
- ▶ Bursty nature: Few superproducers, many non-fertiles

How may mathematical ingenuity condensate?

- ▶ in number of student?
- ▶ in number of fertile students (who also produce students)?

Most students (<1950)

1	Ronold W. P. King	1932	5/100	(5.0%)
2	Leonard S. Ornstein	1908	5/95	(5.3%)
3	Yurii A. Mitropolsky	1938	3/87	(3.5%)
4	Ludwig Prandtl	1899	10/86	(11.6%)
5	Selim Grigorievich Krein	1942	10/81	(12.4%)

Most fertile students

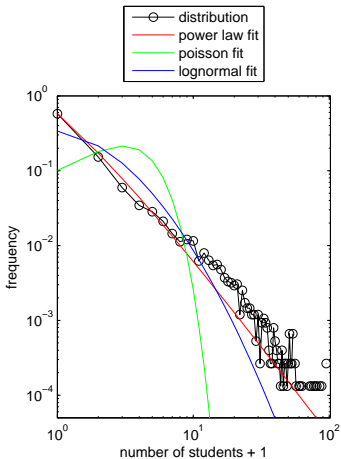
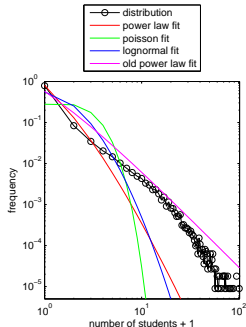
1	Andrei N. Kolmogorov	1925	39/80	(48.8%)
2	Reinhold Baer	1927	30/58	(51.7%)
3	David Hilbert	1885	30/76	(39.5%)
4	Beno Eckmann	1942	28/72	(38.9%)
5	Robert L. Moore	1905	27/50	(54.0%)

Number of:

Persons	121003	
Persons with 2 advisors	13503	(11.2%)
Persons with 1 advisor	91807	(75.9%)
Persons with no advisor	15693	(13.0%)
Persons with no advisor and no student	7350	(6.1%)
Persons with no advisor and 1 student	5313	(4.4%)
Persons without year	8613	(7.1%)

Consequences:

- ▶ After estimation of unknown years 750 persons remain without
- ▶ Exclude always: isolated persons, persons without year still **113586, 92.3%**
- ▶ Option to exclude: person with no advisor and 1 student (non-math supervisor?)

No persons with 0 advisors and 0 studentsDistribution of number of 1st-advised students s plus 1Older than 1950 ($N = 7763$)All ($N = 113586$)

Dynamics

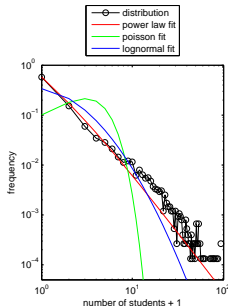
1. Advisors occur at a constant rate
2. An advisor itself counts as its first student
3. With each new advisor m new students occur
4. Students attach to advisors with probabilities **proportional** to their current number of students

$$P(s) \propto \frac{B(s, \gamma)}{B(1, \gamma)}, \quad \gamma = 2 + \frac{1}{m}$$

Best fit achieved for $m = 2.69 \Leftrightarrow \gamma = 2.37$.

²According to Newman 2004

older than 1950 ($N = 7763$)



Problems

- ▶ m not detected empirically
- ▶ Advisors die!

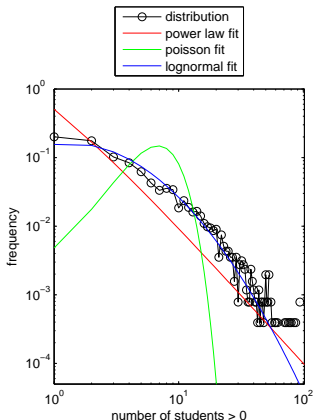
Distribution 2: number of students

No persons with 0 advisor and less than 1 students

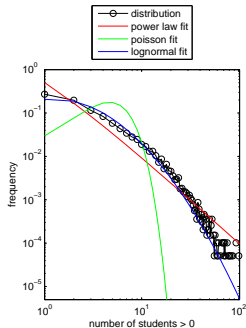
Distribution of number of 1st-advised students s for $s > 0$

only fertile persons (professors)!

Older than 1950 ($N = 7763$)



All ($N = 113586$)



Lognormal theory: Multiplicative growth

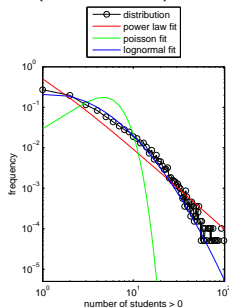
Dynamics

1. A professor **initially** has $s(0) = 0$ so there are $u(0) = 1$ people who might attract students (itself)
2. At time t there are $u(t) = s(t) + 1$ to **attract** new students.
3. **Proportional growth:**
 $u(t+1) = \text{round}[\eta(t)u(t)]$ with $\eta(t) \geq 1$ a random number
4. Always $s(t) = u(t) - 1$ (without professor).

$$s(t) \sim \log \mathcal{N}(t\mu, t\sigma^2) \quad \text{for larger } t$$

No persons with 0 advisor and less than 1 students

all ($N = 113586$)

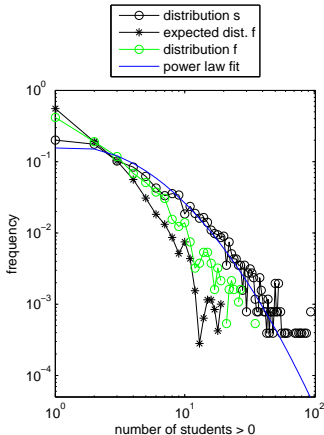
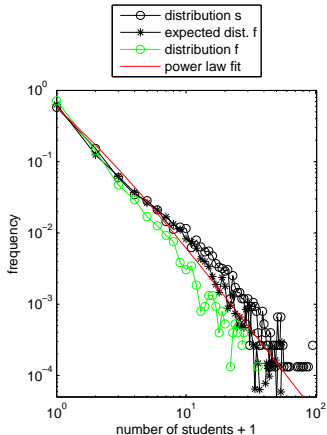


Problems

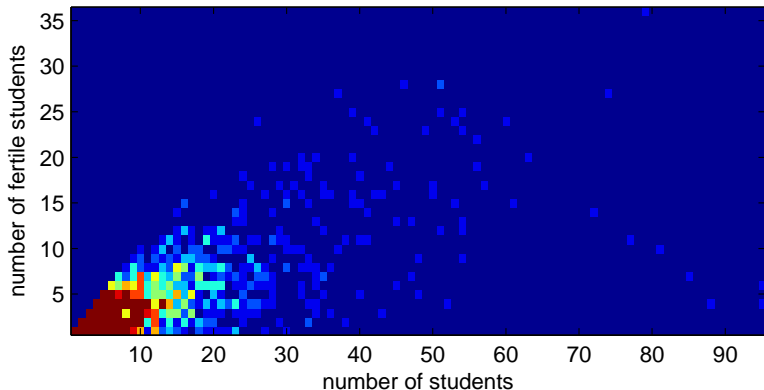
- ▶ what t_{\max} ?
- ▶ distribution of η ?

Persons	121003	
Fertile persons, at least 1 student	26966	(22.3%)
Fertile persons, at least 1 1st-advised student	23662	(19.6%)
Average number of students	0.98	
Average number of students from fertiles	4.41	
Average number of fertile students	0.17	
Average number of fertile students from fertiles	0.78	

Distribution: number of fertile students



- ▶ Number of Students as 1st advisor vs. number of fertile students as 1st advisor



Only mild hints on a nontrivial relation of number of students and the number of fertile students

Further Ideas

- ▶ See it as a branching process and check theoretical with empirical probability of extinction
- ▶ Check the impact of
 - ▶ **Pedigree decline:** How many precessors you have at level l compared to the possible number
 - ▶ **Age impact:** Every advisor relation determines an age by year of advisor graduation minus year of student graduation