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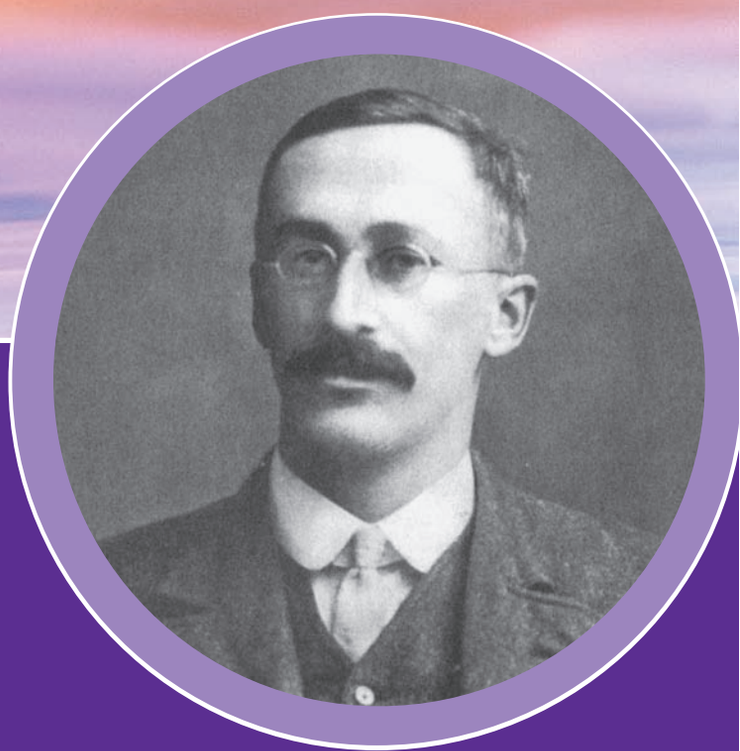
## In this issue





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The cover illustration shows William Sealy Gosset (1876 – 1937), the pioneering statistician whose contribution to that branch of mathematics is amply described in the editorial of this issue. It only remains to note as an interesting aside that while the general formula for deriving the popular black stout was in common use elsewhere, a local tradition declares that the modification which made the product unique was based on a fortuitous miscalculation attributed to Richard Guinness who worked as a brewer for the Archbishop of Cashel in the south of Ireland, and whose son Arthur established the brewery at St. James's Gate in Dublin.

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## Editorial

# The statistical legacy of William Sealy Gosset ("Student")

The work *The Probable Error of a Mean* that led to today's *t*-distribution was the lead article in the March 1908 issue of *Biometrika*. Its author was William Sealy Gosset [1876-1937], who -- for proprietary reasons -- wrote under the pen name "Student." With an Oxford degree in mathematics and chemistry, Gosset began work at the Guinness brewery in Dublin in 1899. Those who still misspell his surname today –as of this writing, the list includes the website of his own employer -- might find it easier to remember the correct spelling if they realized that the Gossets came from Huguenot stock, that the name on the family crest refers to "trois Goussés de fèves feuillées et tigées, et rangées, en pairle de meme" and that it was transmuted to Gosset when his forbears settled in the Channel Island of Jersey

The first of his more than 20 statistical papers, published in 1907 while he was on sabbatical leave at Karl Pearson's unit at University College, dealt with statistical variations in the counting of (yeast) cells. In it, he independently derived the Poisson distribution. Moreover, he used statistical techniques for correlations and goodness of fit developed by Pearson in the previous ten years to test the fit of this theoretical distribution to several sets of experimental data. In 1935, he moved back to his native England to set up a Guinness brewery in Park Royal in London.

Gosset died at the age of 61 in 1937. His friend E S Beaven, a barley breeder, wrote an obituary in the London Times. In it, he revealed Gosset's pen name, and described him as one of a "new generation of mathematicians who were founders of theories now generally accepted for the interpretation of industrial and other statistics." The 1939 *Biometrika* tribute by his Guinness colleague McMullen warmly described " "Student" as a Man." "Student" as Statistician" by Egon Pearson also described his warm personal relationship with Gosset, and reviewed Gosset's groundbreaking statistical work, his links with Karl Pearson and Ronald Fisher, and how Gosset remained a friend of both of these temperamental men.

Fisher, who never again published in *Biometrika* after his early dealings with its editor Karl Pearson, wrote his appreciation of Gosset in the Annals of Eugenics (now the Annals of Human Genetics). He asked Gosset's wife Marjory for a suitable photograph of Gosset. She replied that he didn't like to be photographed in his later years, but she could supply "one fairly good photo of him taken about 1908, but I suppose that wouldn't do." He used it as the frontispiece for the issue of the journal; this photo is the source for the image used in this 2008 tribute. And, thanks to Stephen Ziliak's book, we now know that Gosset's nom-de-plume may well have derived from a manufacturer's imprint on the cover of "Student's" first small sample notebook, "The Student's Science Notebook, Eason and Son, Ltd., Dublin and Belfast," 1905-1907, which "Student" used while on sabbatical at Karl Pearson's Biometric Laboratory. His notebooks contain the results of the statistical simulations, and his mathematical derivations. He used the simulations to check the form of his theoretical curves, since he was not entirely confident that they were mathematically correct.

In Fisher's obituary, W. S. Gosset is described as "one of the most original minds in contemporary science." Fisher goes on, "Without being a professional mathematician, he first published, in 1908, a fundamentally new approach to the classical problem of the theory of errors, the consequences of which are only still gradually coming to be appreciated in the many fields of work to which it is applicable. The story of this advance is as instructive as it is interesting."

And indeed it is. The "different distribution curves for the behaviour of means based on different sample sizes" were the impetus for Fisher to develop the idea of degrees of freedom, and analysis of variance. The concept of the former is still difficult for students today; this author likes to describe the number of degrees of freedom as the *number of independent assessments of error*. In the 1939 tribute to Gosset, Fisher upbraided Karl Pearson -- Gosset's supervisor while he wrote the seminal 1908 paper – for his insistence on using a divisor of $n$, rather than $n-1$, to estimate the variance. Gosset had studied Airy's Theory of Errors, and must have read there that the use of $n-1$ leads to an unbiased estimator. Indeed, in a letter to a Dublin colleague in May 1907, he wrote "when you only have quite small numbers, I think the formula with the divisor of $n-1$ we used to use is better" But Karl Pearson, scoffed that it doesn't matter, "because only naughty brewers take $n$ so small that the difference is not of the order of the probable error!"

Gosset's limited mathematical statistics capacity and vision did not allow him to see how his table could be used for a much broader array of statistical analyses than the simple 1-sample or paired sample situations he illustrated in his 1908 paper. It was Fisher who saw, and in 1925 fully described, the many extensions of Gosset's work, not just to the familiar 2-independent-samples context, but also to correlation and regression coefficients. Fisher also convinced Gosset to leave behind the ratio, $z = (\bar{y}-\mu)/s$ , whose sampling distribution he had originally derived, for the ratio we learn today, $t= (\bar{y}-\mu)/(s/\sqrt{n})$, and in which – unlike the use of the divisor of $n$ that Pearson insisted on -- the standard deviation $s$ is now estimated using the degrees of freedom $n-1$ as the divisor.

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However, it was Gosset who chose the letter *t*. It, and the fact that it was "Student's" *t*, became immortalized when Fisher described them in his book Statistical Methods for Research Workers. While the original tables began to be used inside the brewery from 1908 onwards, they were also used by a pioneer epidemiologist outside the brewery as early as 1912.

Despite his modest mathematics, Gosset also provided the impetus for two important developments in the design of experiments, and in the philosophical foundations of one school of statistical inference. One concerned the principles of experimental design. Gosset had firm ideas on how to use matching and blocking to reduce variation in agricultural experiments, and he and Fisher had some heated arguments about this, and about how best to use randomization. The other was a pre-occupation with what "should matter" when interpreting statistical results. Egon Pearson credits Gosset with some of the ideas that led Neyman and Egon Pearson to develop their theory for hypothesis testing. Clearly, in his worked agricultural examples in his 1908 paper, Gosset's concern was not just what is good for Guinness, but also what is good for the farmer: whereas Guinness may have been interested just in the quantity and quality of the barley corn, the farmer was interested in a different bottom line, one that includes the price he would get not just for the corn, for also for the straw! Ziliak and McCloskey examined the annual reports of Guinness, and followed his interactions with Fisher and the Pearsons, and argue that Gosset's pecuniary viewpoint was hijacked by Fisher, and by Neyman and Pearson, who seemed more pre-occupied with p-values and statistical tests, while Gosset would have preferred the modern-day emphasis – in some quarters at least -- on confidence intervals.

From the outset, Gosset was concerned with how to include financial considerations in the planning and analysis of experiments, and sought out Karl Pearson to discuss these challenges. His concerns were never adequately dealt with by Pearson, or by Fisher. But we thank him for his concerns with the practical, and the realistic, and for motivating others to develop many of the statistical approaches and techniques we use today.

According to Fisher, "of (Gosset's) personal characteristics, the most obvious were a clear head, and a practice of forming independent judgements." The other was the importance of his work environment: "one immense advantage that Gosset possessed was the concern with, and responsibility for, the practical interpretation of experimental data." Today's teachers and internship mentors should emphasize these at the earliest stages in the training of community health researchers and methodologists.

I end with two items that are relevant to today's "students," a term should have no age limit. The first is a quote from Egon Pearson. While it is aimed at research students in statistics, it applies to a much wider, and modern, readership. In his appreciation of Gosset, Pearson remarked on the quality of his writing and communication and commended the 1908 article to all contemporary "students" and their teachers, "It is a paper to which I think all research students in statistics might well be directed, particularly before they attempt to put together their own first paper."

The second is Gosset's critique of a nutritional experiment on a very large scale was carried out in the schools of Lanarkshire.

I commend this to all readers for its humanity and clarity, and for the absence of the arrogance and 20-20 retrospective vision that pervade many of today's letters to the editor. It also emphasizes that sophisticated statistical analysis can seldom rescue information from data collected in seriously flawed designs.

We should celebrate the last century of developments in experimental design and methods of statistical analysis, and of the colourful individuals behinds them. But we should not use these methods blindly. Rather, as Gosset would have had us do, we should be concerned with, and take responsibility for, the practical interpretation of our experimental data.

During the 2008 Biometrics Conference, the Irish Statistical Association unveiled a plaque to the memory of Gosset at the Guinness storehouse at St. James's Gate in Dublin. In attendance at the unveiling ceremony were two of Gosset's grandchildren, one of whom was born just 6 months before Gosset died. Photographs from this historic occasion can be found under "Photos from IBC 2008 in Dublin" on the website of The International Biometric Society (http://www.tibs.org)

## References


Hanley JA, Julien M, Moodie EEM. Student's z, t, and s: What if Gosset had R? *The American Statistician*, February 2008, Vol. 62, No. 1. pp. 64-69.

Student. On the Error of Counting with a Haemacytometer. *Biometrika*, Vol. **5,** No. 3. (Feb., 1907), pp. 351-360.

Student. The probable error of a mean. *Biometrika* Vol 6, No. 1, (March 1908). 1-25.

Student. The Lanarkshire Milk Experiment *Biometrika*, Vol. **23**, No. 3/4. (Dec., 1931), pp. 398-406.

Winkelstein, W. Vignettes of the History of Epidemiology: Three firsts by Janet Elizabeth Lane-Claypon. *American Journal of Epidemiology*, **160**(2) 2004;160:97–101.

Ziliak ST, McCloskey DN. The Cult of Statistical Significance: How the Standard Error Costs Us Jobs, Justice, and Lives. University of Michigan Press, 2007

Ziliak ST. "Guinnessometrics: The Economic Foundation of 'Student's' *t*," Journal of Economic Perspectives, Fall 2008, vol. **22** (4), forthcoming.