What is Statistics?

- The science of collecting, organizing, and interpreting data.
- The logic of drawing conclusions from uncertain information.

What is Statistics Good For?

- Scientific inference:
  - Are human activities making the Earth warmer?
  - Do two varieties of moths mate at different times?
- Personal and public decision making:
  - Should you invest in the stock market?
  - Should donated blood be tested for Hepatitis C?
- Engineering:
  - Correcting errors in transmitted data.
  - Recognizing handwritten computer input.

Statistical Concepts in this Course

- Collecting data (experiments, sampling).
- Presenting and summarizing data.
- Interpreting relationships.

- Probability.
- Concepts of formal statistical inference.
- Inference in some simple situations.

- More advanced topics in inference: Multiple regression, Contingency tables, Analysis of variance

Exploratory Analysis of Data

The Old Faithful geyser in Yellowstone National Part in Wyoming erupts fairly regularly, but the time intervals between eruptions are not exactly the same.

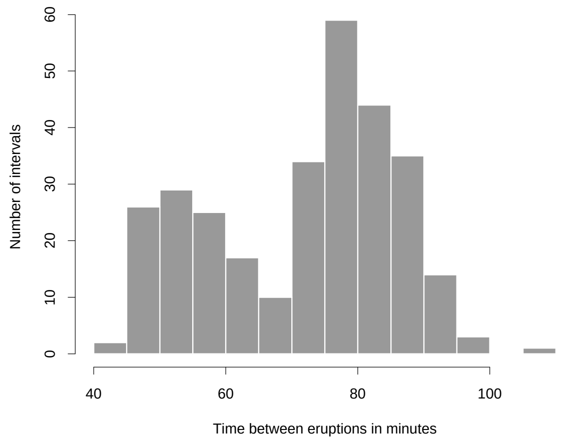
Is there some sort of pattern to the times between eruptions? Could this tell us something about how geysers work?

Can we predict the next eruption time better if we know how long the interval between the last two eruptions was?

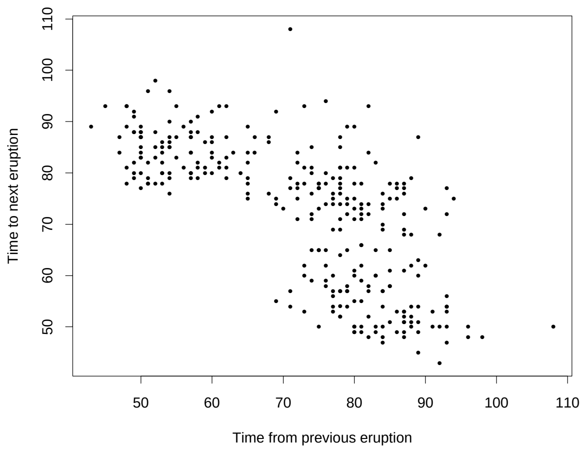
Reference:

Azzalini, A. and Bowman, A. W. (1990) “A Look at Some Data on the Old Faithful Geyser”, *Applied Statistics*, vol. 39, pp. 357-365.

Histogram of Time Intervals Between Geyser Eruptions



Scatterplot of Next Interval Versus Previous Interval



Formal Inference for an Experiment

Cotton plants have been genetically engineered to produce a toxin from a bacterium, *Bacillus thuringiensis* (*Bt* for short). This reduces infestation by bollworm moths.

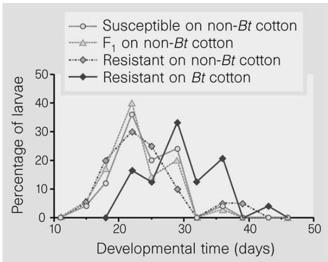
But the moths can develop resistance. To slow this process, some non-*Bt* cotton is grown with the *Bt* cotton, so that non-resistant moths will mate with the resistant moths.

Possible problem: What if the resistant and non-resistant moths take difference amounts of time to develop? Then they wouldn't be available to mate with each other.

Reference:

Liu, Y.-B., *et al* (1999) "Development time and resistance to *Bt* crops", *Nature*, vol. 400, p. 519.

Development Time in Resistant Moths



Development of pink bollworm larvae on *Bt* and non-*Bt* cotton plants. Pieces of paper, each with 20-40 eggs, were placed under the bracts of 74 bolls of 16 *Bt* cotton plants (Delta Pine 50B) and 10 non-*Bt* cotton plants (Delta Pine 50) in a greenhouse. After a week, we counted a total of 1,411 entrance holes made by neonates. After two weeks, bolls were caged, and twice a week we counted mature larvae that had exited from bolls. For each strain, survival on *Bt* cotton was estimated by adjusting for mortality on non-*Bt* cotton using Abbott's correction. The resistant strain (APHIS-98R) developed significantly more slowly in bolls of *Bt* cotton (29.8±1.1 days) than the susceptible strain (APHIS-S) did in bolls of non-*Bt* cotton (24.1±0.9) (t-test, t=3.89, d.f.=47, $P < 0.001$). Developmental time on non-*Bt* cotton did not vary significantly among the resistant strain, the susceptible strain and the F_1 progeny.

The Globe and Mail

Letter to the Editor, 17 July 1998, page A16

A university degree leads to better employment prospects and higher earnings over the long term than any other type of education.

The unemployment rate for the total Canadian labour force was 9.4 per cent in 1996, whereas people with university degrees had the lowest rate of unemployment at only 4.6 per cent.

University degrees also lead to higher average income. Statistics Canada reported in 1995 that the average income for people in Canada with university degrees was $41,851, followed by $23,827 for those with secondary and some postsecondary education, and $17,053 for people with less than a Grade 9 education. In fact, higher educational attainment continues to have higher payoffs as people with master's degrees earn more on average than those with bachelor's degrees, just as doctoral graduates earn more on average than master's graduates

Ian Clark, President,
Council of Ontario Universities, Toronto

The Globe and Mail

News Item, 29 August 1998, page D5

Are renters more neurotic?

People who rent apartments rather than own condos and who are car-less are more neurotic than other people, says a British study. In a survey of nearly 10,000 Brits, Glyn Lewis and colleagues at the University of Wales College of Medicine in Cardiff found that people who rented their homes were about 30 per cent more likely to have a neurotic disorder than homeowners. And those who lacked access to two or more cars were about 40 per cent more likely to have emotional problems.

Experiment vs. Observation

If the experiment with bollworms was done correctly, we can be confident that the resistant bollworms on *Bt* cotton took longer to develop *because* they were on *Bt* cotton.

But what can we conclude from the non-experimental data in the newspaper items?

- If you want to be wealthy, is getting a university degree a good idea?
- If you want to market an expensive product, is targeting university graduates a good idea?
- Would giving everyone a house and two cars reduce mental illness?