The emergence of probability

Mathematics was well developed in the ancient world:
- quadratic equations ~ 1700BC in Mesopotamia
- geometry ~ 500BC in the Greek world
- algebra ~ 1200AD in China, India,..

The Greeks discussed randomness in a qualitative way: Democritus (460BC), Epicurus (341BC) ...

Yet, mathematical theory of probability came very late:
- Gerolamo Cardano (b. 1501, Pavia); Ars Magna 1545 - published solutions of cubic and quartic equations (derived by Tartaglia & Ferrari)
  - 1564 Liber de ludo alaeae - a gambler’s handbook
  - Pascal & Fermat (1654)
  - Bernoulli Ars Conjectandi (1713) & de Moivre The Doctrine of Chances (1718)
  - Laplace Théorie analytique des probabilités (1812)

In physics, probability entered very late:
- Gauss’ theory of errors (~ 1800)
- statistical mechanics (Boltzmann, 1871)
- this probabilistic theory was not accepted until the 20th C
- Einstein (1905) linked macroscopic Brownian motion with atomic properties
- quantum mechanics brought genuine randomness into physics in the 1920’s

Statistics and probability were driven by biological questions:
- Francis Galton pioneered biometrics
- Karl Pearson developed the mathematics of the normal distribution in order to understand inheritance of continuous traits
  - Fisher (1918)
    - showed how continuous variation could be partitioned into components: ANOVA
    - developed modern statistical inference

The course focusses on stochastic models rather than statistical inference - but these are closely connected

What is “probability”?

What do we mean by probability?

Frequency in a long series of trials …
- symmetry arguments (coins, dice, chromosomes…)
- how can we define the probability of a particular set of data? A unique event?

Degree of belief
- probability cannot be entirely subjective
- rational degree of belief (a “fair bet”)?
- can we think of the probability of a theory
  - Bayesian interpretation…
Probability as propensity

- fitting a probabilistic model

  e.g. the probability of a hot summer (Schar et al., Nature, 2004)