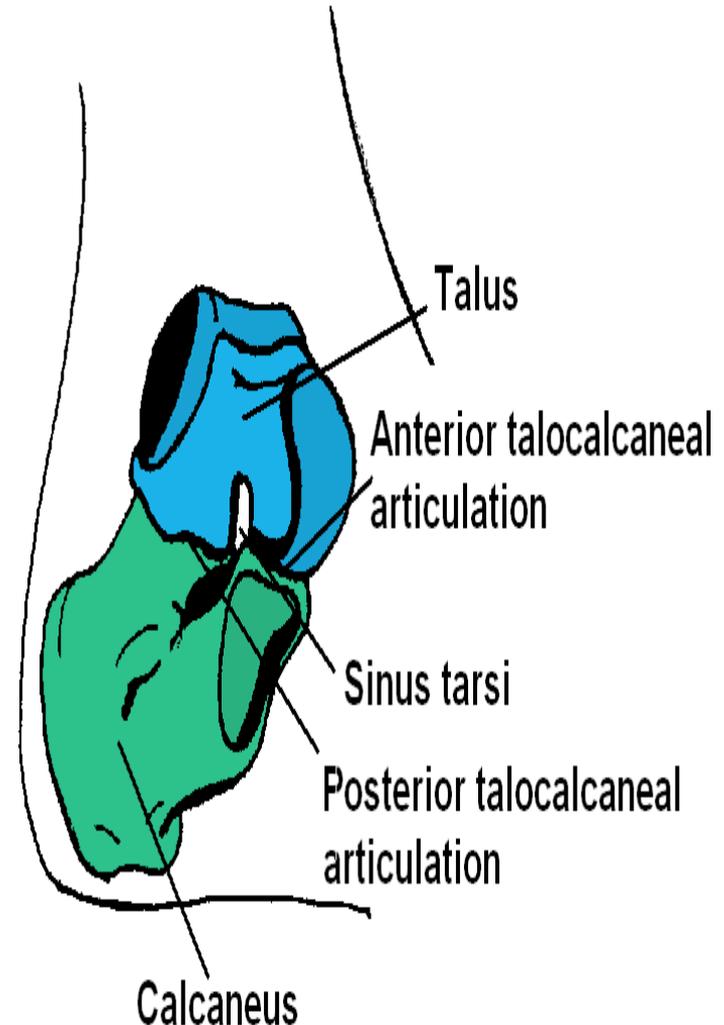


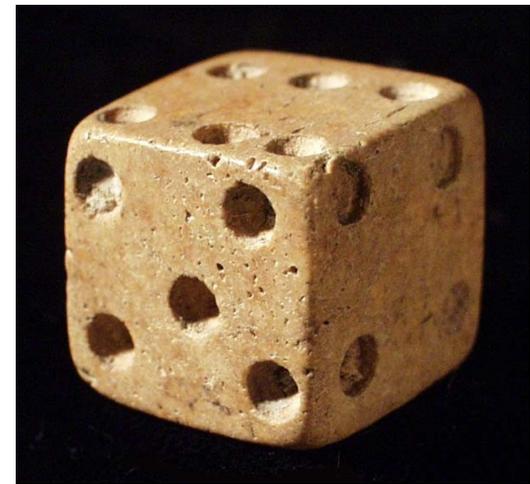
# (Modern) History of Probability

# Part II. Reasoning with Uncertainty: Probability and Statistics

# Ancient History

- Astragali: six sided bones. Not symmetrical.
- Excavation finds: sides numbered or engraved.
- primary mechanism through which oracles solicited the opinions of their gods.
- In Asia Minor: divination rites involved casting five astragali.
- Each possible configuration was associated with the name of a god and carried the sought-after advice. An outcome of (1,3,3,4,4), for instance, was said to be the throw of the savior Zeus, and was taken as a sign of encouragement. A (4,4,4,6,6), on the other hand, the throw of the child-eating Cronos, would send everyone scurrying for cover.





- astragali were replaced by dice
- Pottery dice have been found in Egyptian tombs built before 2000 B.C
- Loaded dice have also been found from antiquity.
- The Greeks and Romans were consummate gamblers, as were the early Christians.
- The most popular dice game of the middle ages: "hazard"
- Arabic "al zhar" means "a die."
- brought to Europe by soldiers returning from the Crusades,
- Rules much like modern-day craps.
- Cards introduced 14<sup>th</sup>
- Primero: early form of poker.
- Backgammon etc were also popular during this period.
- The first instance of anyone conceptualizing probability in terms of a mathematical model occurred in the sixteenth century

- “Calculus of probabilities”: incompatible Greek philosophy and early Christian theology.
- Greeks not inclined to quantify random events in any useful fashion.
- reconciling mathematically what did happen with what should have = an improper juxtaposition of the “earthly plane” with the “heavenly plane.”
- Greeks accepted “chance”, whimsy of gods, but were not empiricists: Knowledge was not something derived by experimentation.
- “stochastic” from “stochos”: target, aim, guess
- Early Christians: every event, no matter how trivial, was perceived to be a direct manifestation of God’s deliberate intervention
- St. Augustine: “We say that those causes that are said to be by chance are not nonexistent but are hidden, and we attribute them to the will of the true God...”

- Cardano : trained in medicine, addicted to gambling
- Sought a mathematical model to describe abstractly outcome of a random event.
- Formalized the classical definition of probability: If the total number of possible outcomes, all equally likely, associated with some actions is  $n$  and if  $m$  of those  $n$  result in the occurrence of some given event, then the probability of that event is  $m/n$ .
- EX: a fair die roll has  $n= 6$  possible outcomes. If the event “outcome is greater than or equal to 5” is the one in which we are interested, then  $m = 2$  (the outcomes 5 and 6) and the probability of the even is  $2/6$ , or  $1/3$ .
- He wrote a book in 1525, but not published until 1663



# The Problem of Points

The date cited by many historians as the “beginning” of probability is 1654.

Chevalier de Mere asked Blaise Pascal, and others:

- Two people, A and B, agree to play a series of fair games until one person has won six games. They each have wagered the same amount of money, the intention being that the winner will be awarded the entire pot. But suppose, for whatever reason, the series is prematurely terminated, at which point A has won five games and B three. How should the stakes be divided?
- The correct answer is that A should receive seven-eighths of the total amount wagered.



- Pascal corresponds with Pierre Fermat
- famous Pascal-Fermat correspondence ensues
- foundation for more general results.
- ...Others got involved including Christiaan Huygens.
- In 1657 Huygens published *De Ratiociniis in Aleae Ludo* (Calculations in Games of Chance)
- What Huygens actually wrote was a set of 14 Propositions bearing little resemblance to modern probability... but it was a start



- Probability theory soon became popular... major contributors included Jakob Bernoulli (1654-1705) and Abraham de Moivre (1667-1754).
- In 1812 Pierre de Laplace (1749-1827) "Théorie Analytique des Probabilités."
- Before Laplace: mathematical analysis of games of chance.
- Laplace applied probabilistic ideas to many scientific and practical problems:
- Theory of errors, actuarial mathematics, and statistical mechanics etc 19th century.



- Now applications of probability extend to...
- Mathematical statistics
- genetics, psychology, economics, and engineering.
- Main contributors: Chebyshev, Markov, von Mises, and Kolmogorov.
- The search for a widely acceptable definition of probability took nearly three centuries and was marked by much controversy.
- A. Kolmogorov (1933): **axiomatic approach** "Foundations of Probability" now part of a more general discipline known as measure theory."



[Dice are “descendents” of bones]

- A. True
- B. False

[Mathematical theory of probability was initiated by Pascal and Fermat]

- A. True
- B. False