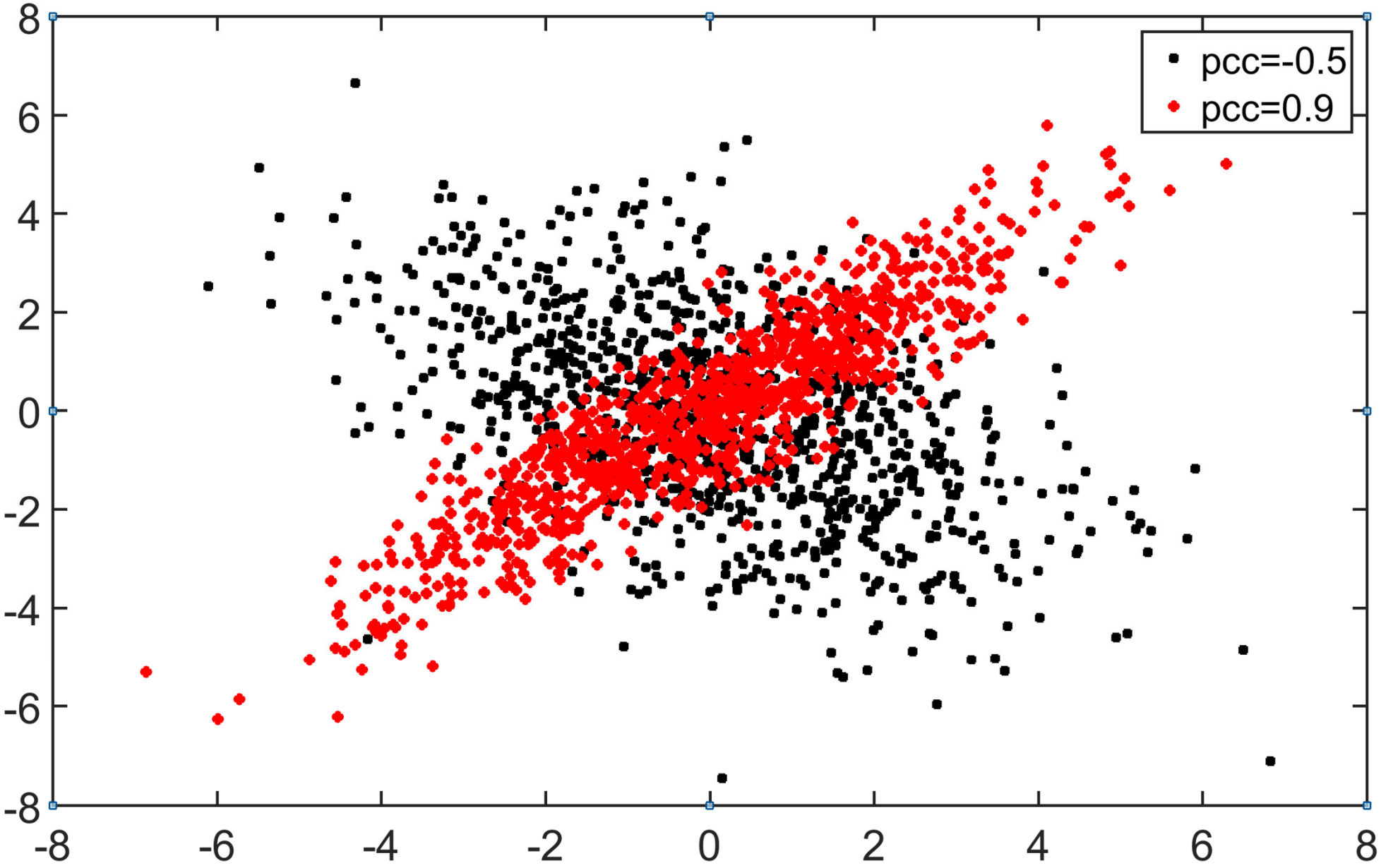
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pcc=0.9
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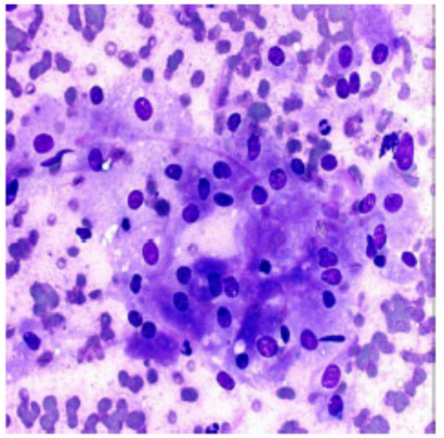
6
4
2
0
-2
-4
-6
-8
-8
-6
-4
-2
0
2
4
6
8

Let's work with real cancer data!

- Data from Wolberg, Street, and Mangasarian (1994)
- Fine-needle aspirates = biopsy for breast cancer
- Black dots – cell nuclei. Irregular shapes/sizes may mean cancer
- Statistics of all cells in the image
- 212 cancer patients and 357 healthy individuals (column 1)
- 30 other properties (see table)



Variable	Mean	S.Error	Extreme
Radius (average distance from the center)	Col 2	Col 12	Col 22
Texture (standard deviation of gray-scale values)	Col 3	Col 13	Col 23
Perimeter	Col 4	Col 14	Col 24
Area	Col 5	Col 15	Col 25
Smoothness (local variation in radius lengths)	Col 6	Col 16	Col 26
Compactness (perimeter^2 / area - 1.0)	Col 7	Col 17	Col 27
Concavity (severity of concave portions of the contour)	Col 8	Col 18	Col 28
Concave points (number of concave portions of the contour)	Col 9	Col 19	Col 29
Symmetry	Col 10	Col 20	Col 30
Fractal dimension ("coastline approximation" - 1)	Col 11	Col 21	Col 31

Matlab exercise #2

- Download cancer data in cancer_wdbc.mat
- Data in the table cancerwdbc (569x30). First 357 patients are healthy. The remaining 569-357=212 patients have cancer.
- Make scatter plots of area vs perimeter and texture vs radius.
- Calculate Pearson and Spearman correlations
- Calculate the correlation matrix of all-against-all variables: there are 30*29/2=435 correlations. Hint: corr_mat=corr(cancerwdbc);
- Plot the histogram of these 435 correlation coefficients. Hint: use [i,j,v]=find(corr_mat); then find all i>j and analyze v evaluated on this subset of 435 matrix elements

Credit: XKCD comics

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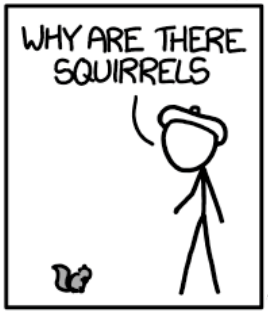

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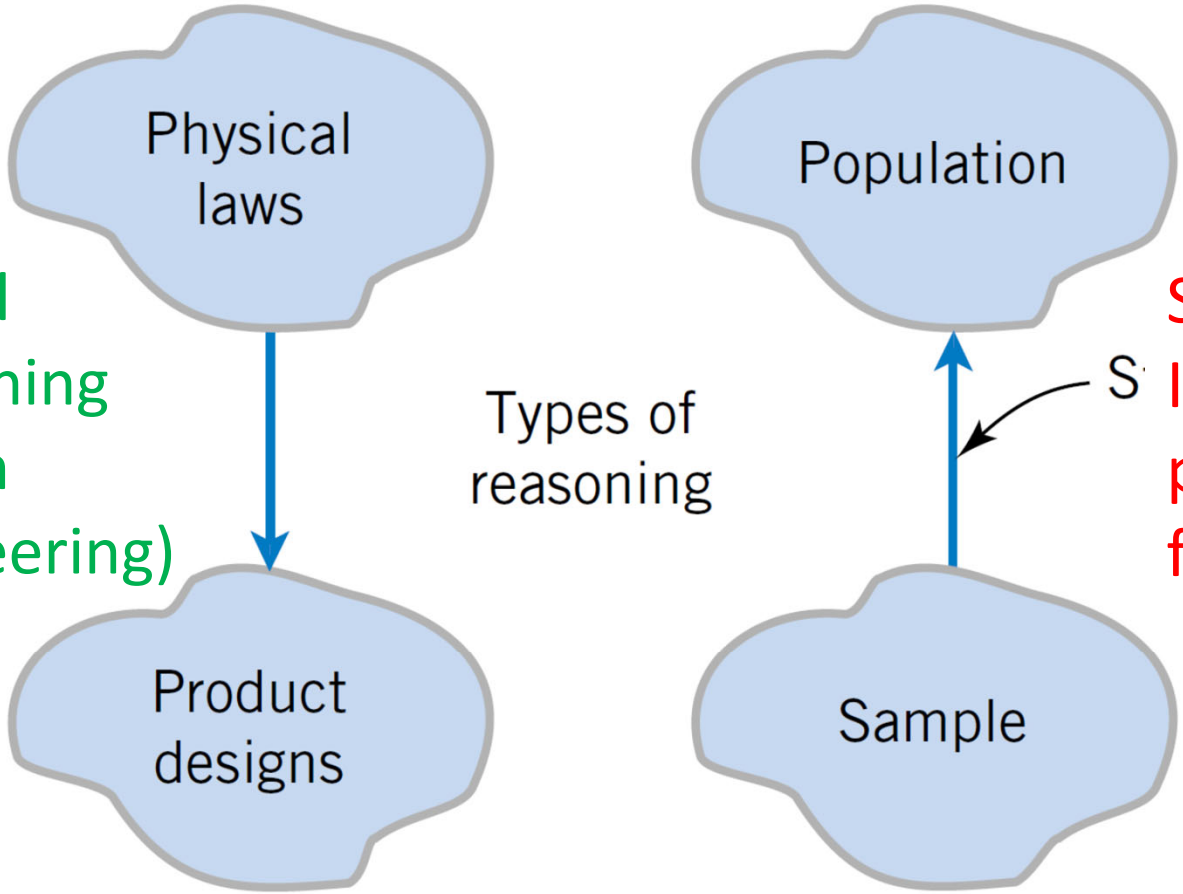
Descriptive statistics:

Populations, Samples

Histograms, Quartiles

Sample mean and variance

Two types of reasoning



Logical Reasoning (e.g. in Engineering)

Statistical reasoning: Inference of population properties from a finite sample

Numerical Summaries of Data

- Data are the numerical observations of a phenomenon of interest.
- The totality of all observations is a population.
  - Population can be infinite (e.g. abstract random variables)
  - It can be very large (e.g. 7 billion humans or all patients who have cancer of a given type)
- A (usually small) portion of the population collected for analysis is a random sample.
- We want to use sample to infer facts about populations
- The inference is not perfect but gets better and better as sample size increases.

Some Definitions

- The random variables $X_1, X_2,\ldots,X_n$ are a random sample of size n if:
  a) The X_i are independent random variables.
  b) Every X_i has the same probability distribution.

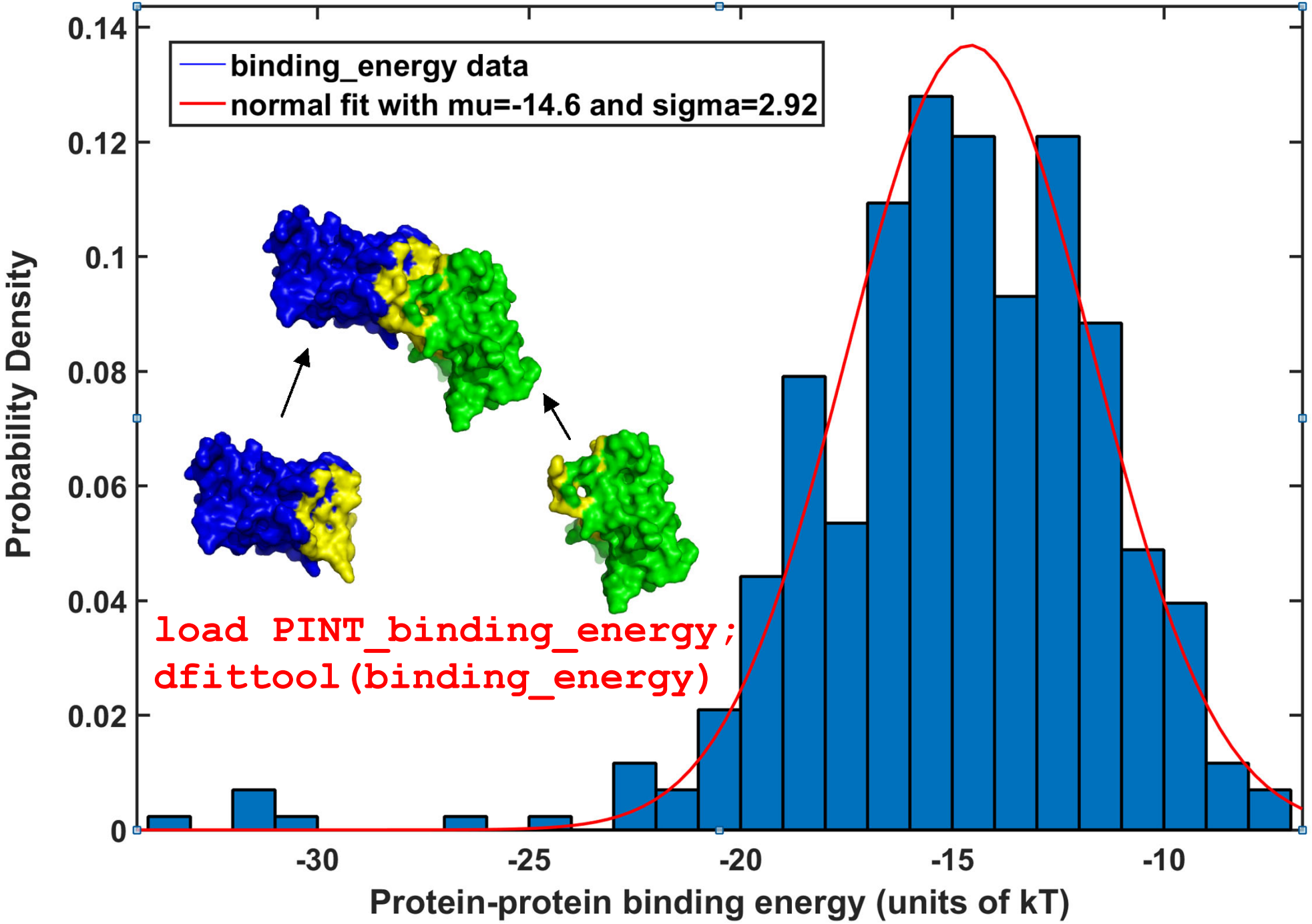
- Such $X_1, X_2,\ldots,X_n$ are also called independent and identically distributed (or i. i. d.) random variables

Ways to describe a sample:

Histogram

approximates PDF

(or PMF)


binding_energy data
normal fit with mu=-14.6 and sigma=2.92
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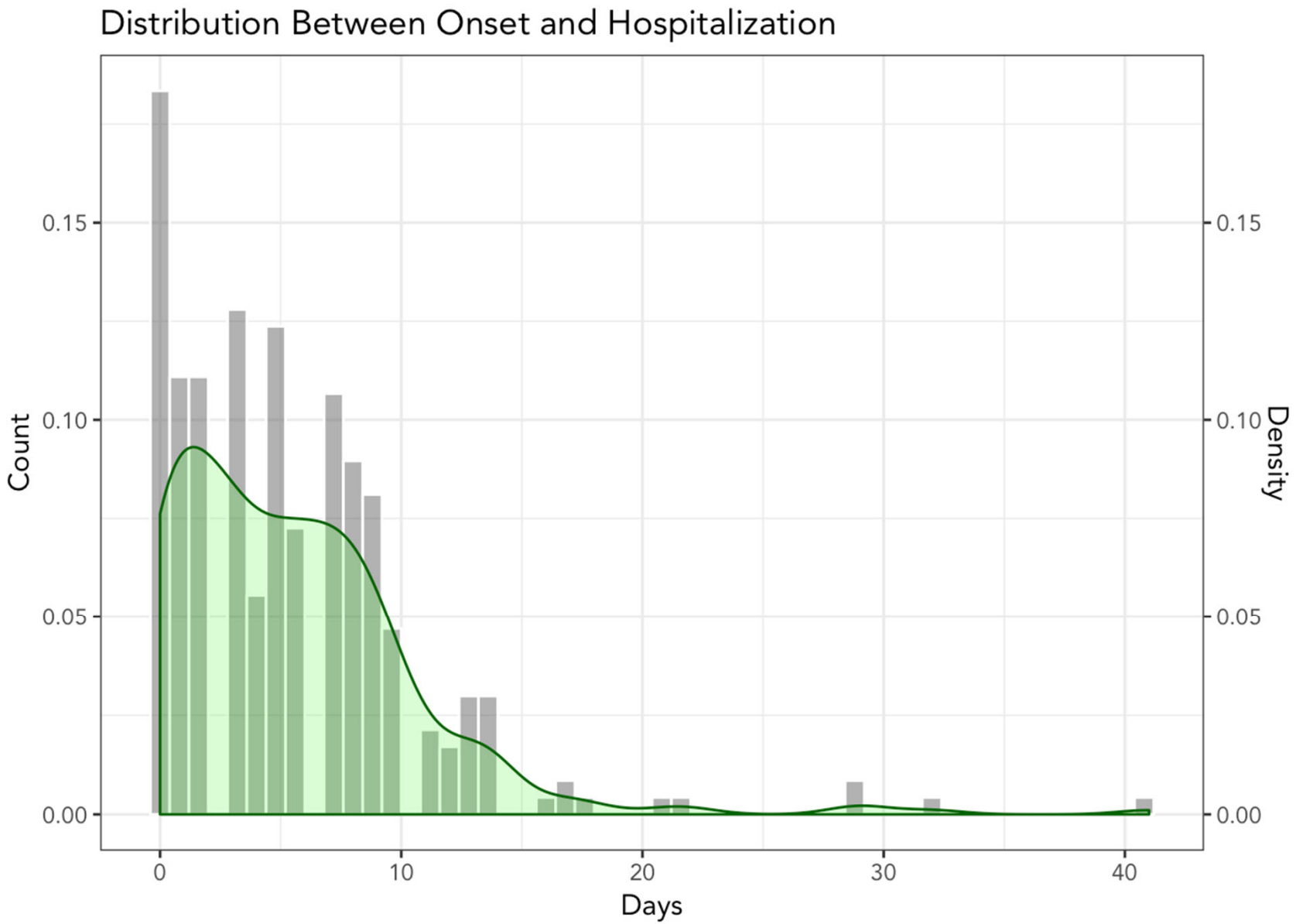
dfittool(binding_energy)
Probability Density
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-30
-25
-20
-15
-10
Protein-protein binding energy (units of kT)

PDF of time between COVID-19 symptoms onset and hospitalization in IL, April 2020

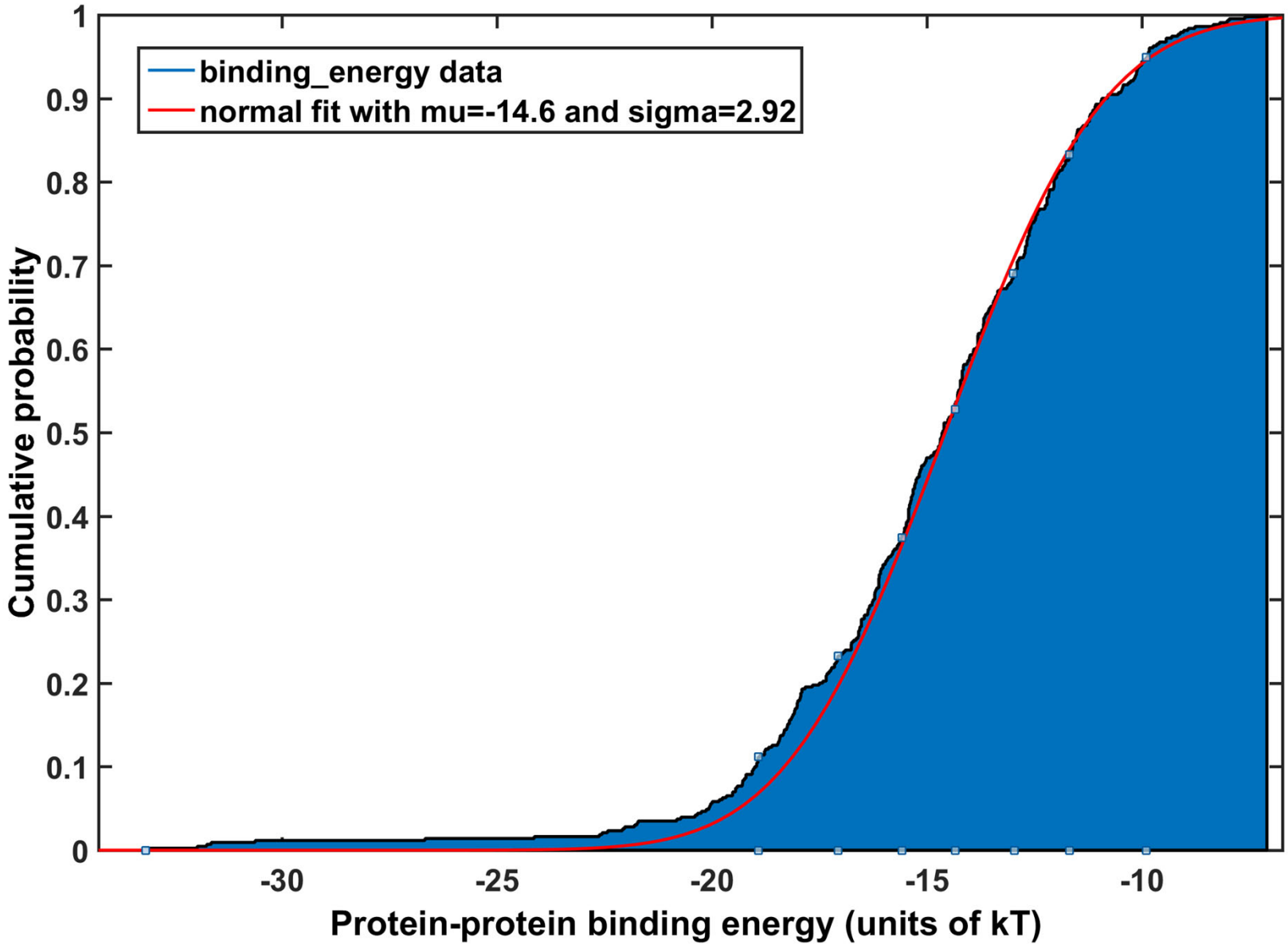


Histograms with Unequal Bin Widths

- If the data is tightly clustered in some regions and scattered in others, it is visually helpful to use narrow bin widths in the clustered region and wide bin widths in the scattered areas.
- To approximate the PDF, the rectangle area, not the height, must be proportional to the bin relative frequency.

$$\text{Rectangle height} = \frac{\text{bin relative frequency}}{\text{bin width}}$$

Cumulative Frequency Plot



Median, Quartiles, Percentiles

- The median q_2 divides the sample into two equal parts: 50% (n/2) of sample points below q_2 and 50% (n/2) points above q_2
- The three quartiles partition the data into four equally sized counts or segments.
  - 25% of the data is less than q_1.
  - 50% of the data is less than q_2, the median.
  - 75% of the data is less than q_3.
- There are 100 percentiles. n-th percentile p_n is defined so that n% of the data is less than p_n

Matlab exercise #1

- Find the median and lower & upper quartiles of a n=100 sample drawn from a continuous uniform distribution in [0,1]
- Do not use built-in Matlab functions for this exercise!
- Hint: use [a,b]=sort(r1); to rank order your sample. The variable a returns r1 sorted in the increasing order.
- How to find the median and both quartiles from a?

How to find the median & quartiles

- % Example: find median and lower quartile of
- % a sample with n=100 drawn from uniform
- r1=rand(100,1);
- [a,b]=sort(r1);
- med=(a(50)+a(51))./2
- sum(r1<med) % verify
- q1=(a(25)+a(26))./2
- sum(r1<q1) % verify

Credit: XKCD comics

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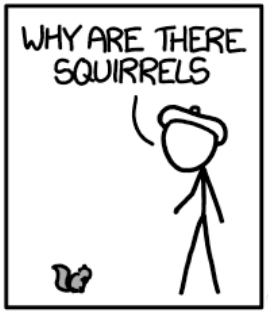

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