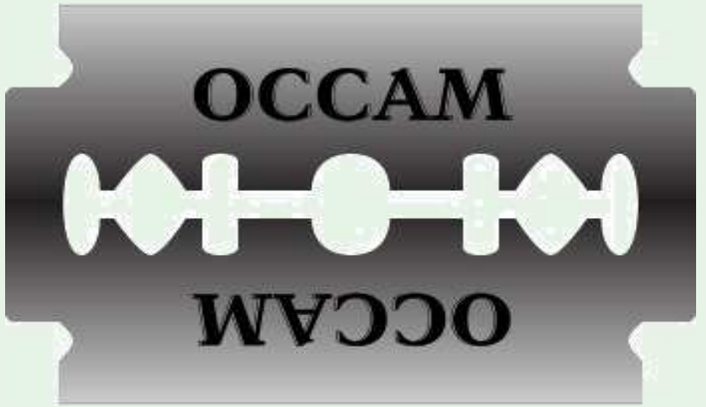
Recurring theme - simple hypotheses

A "quote" by Einstein:

> An explanation of the data should be made *as simple as possible, but no simpler*

The razor: symbolic of a principle set by William of Occam



Occam's Razor

The simplest model that fits the data is also the most plausible.

Two questions:

1. What does it mean for a model to be simple?

2. How do we know that simpler is better?

First question: 'simple' means?

Measures of complexity - two types: complexity of h and complexity of $\mathcal{H}$

Complexity of h: MDL, order of a polynomial

Complexity of $\mathcal{H}$: Entropy, VC dimension

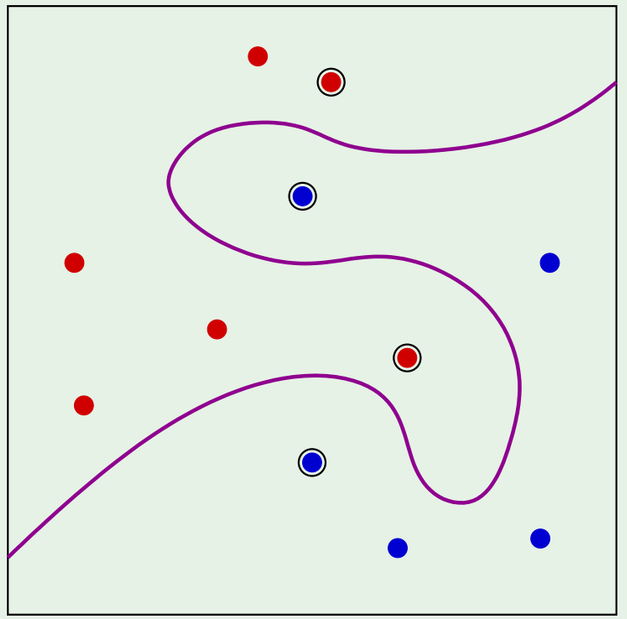
- When we think of simple, it's in terms of h
- Proofs use simple in terms of $\mathcal{H}$

and the link is ...

counting: ℓ bits specify h $\Longrightarrow$ h is one of 2^ℓ elements of a set $\mathcal{H}$

Real-valued parameters? **Example:** 17th order polynomial - complex and one of "many"

Exceptions? Looks complex but is one of few - **SVM**



Puzzle 1: Football oracle

00000000000000001111111111111111	0
00000000111111110000000011111111	1
00001111000011110000111100001111	0
00110011001100110011001100110011	1
01010101010101010101010101010101	1

- Letter predicting game outcome
- Good call!
- More letters - for 5 weeks
- Perfect record!
- Want more? \$50 charge 
- **Should you pay?**

Second question: Why is simpler better?

Better doesn't mean more elegant! It means better out-of-sample performance

The basic argument: (formal proof under different idealized conditions)

Fewer simple hypotheses than complex ones

$$m_{\mathcal{H}}(N)$$

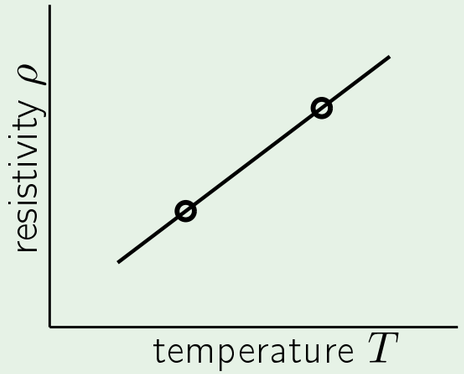
$\Rightarrow$ less likely to fit a given data set

$$m_{\mathcal{H}}(N)/2^N$$

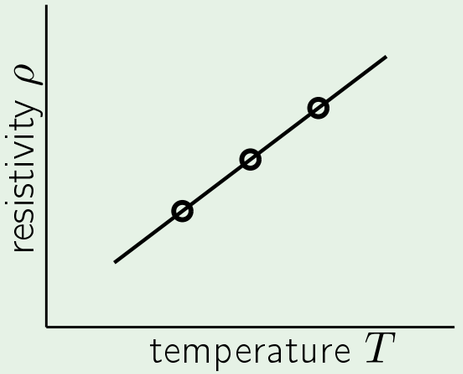
$\Rightarrow$ more significant when it happens

The postal scam: $m_{\mathcal{H}}(N) = 1$ versus 2^N

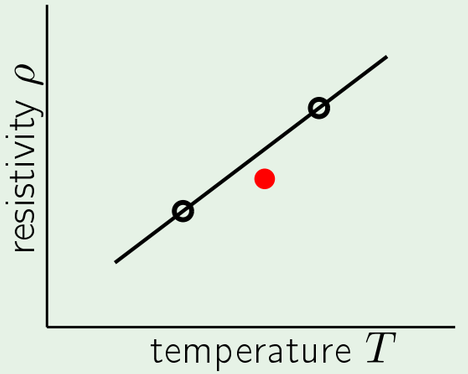
A fit that means nothing



Scientist A



Scientist B



"falsifiable"

Conductivity linear in temperature?

Two scientists conduct experiments

What evidence do A and B provide?