Science and its imitators

Astronomy 101
Syracuse University, Fall 2016
Walter Freeman

October 20, 2016

Announcements

- Next *Mastering Astronomy* assignment posted tomorrow; I'll notify by email
- I'll catch up on responding to email tonight
- The TA's and I are grading exams tonight
- We'll make your grades available ASAP

Multiple choice exam results

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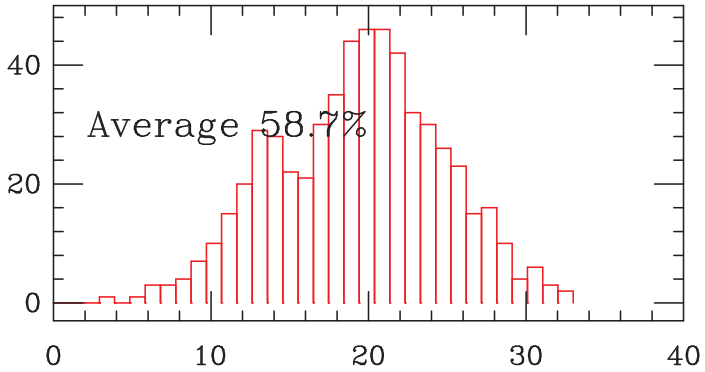

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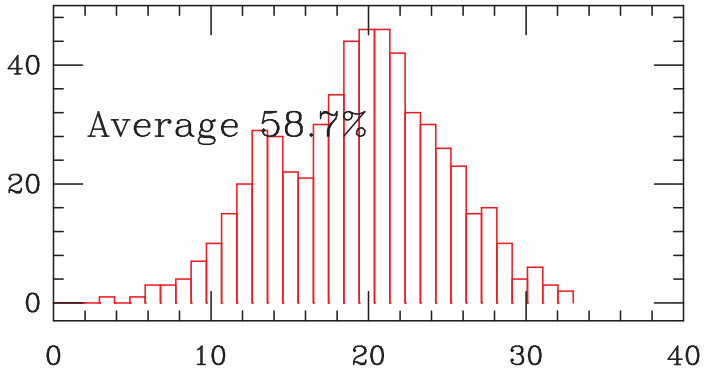

Oops, that was Exam 1.

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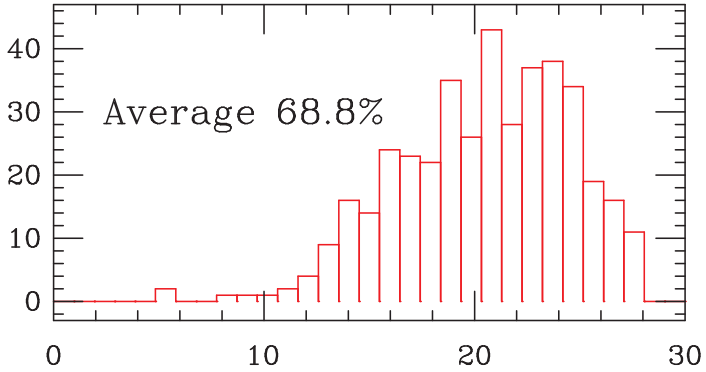

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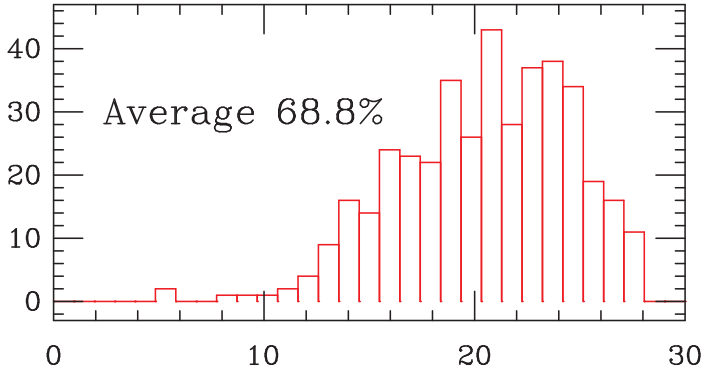

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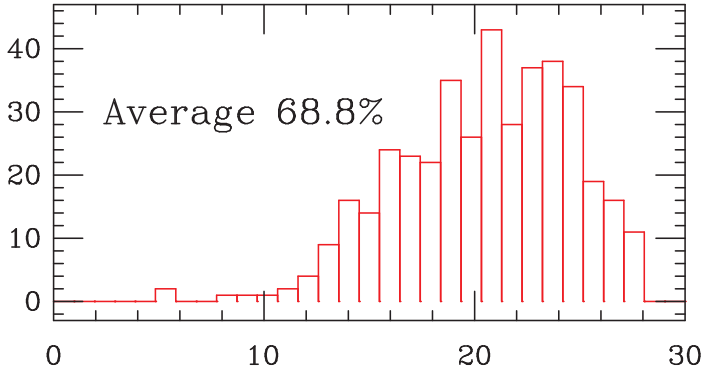

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... something went wrong with the answer key! Let's try again...

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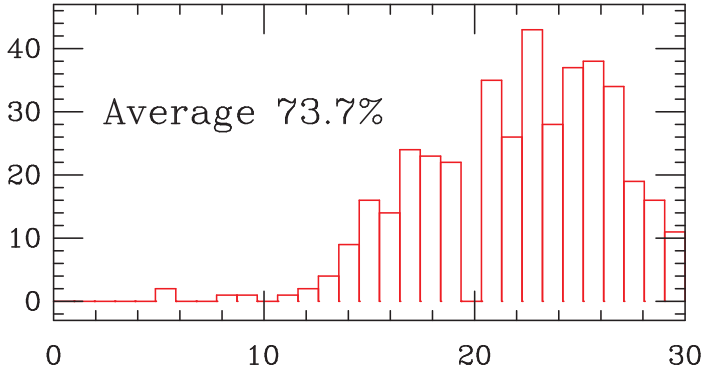

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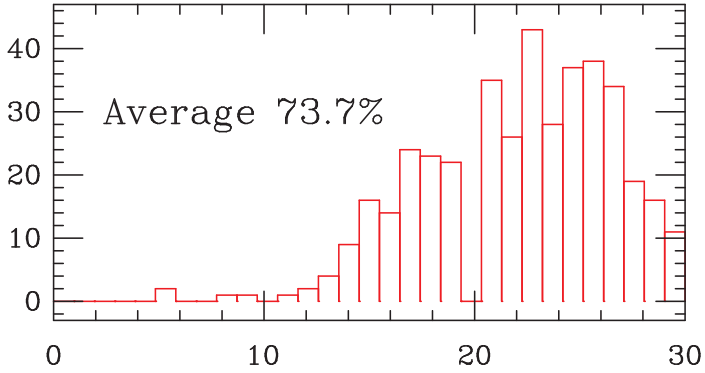

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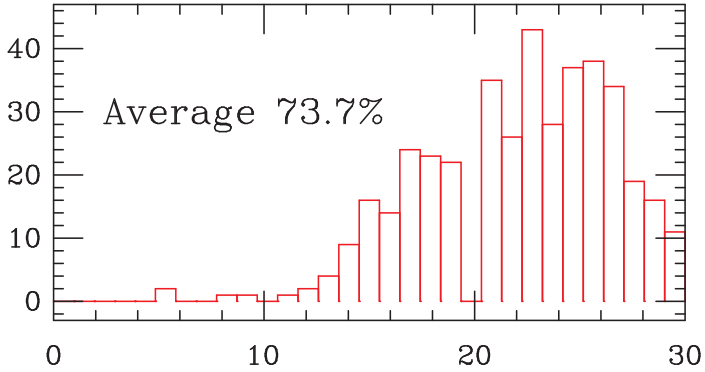

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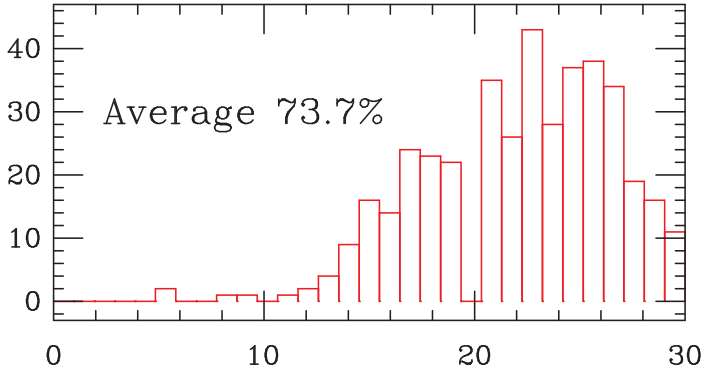

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Wait, that's not a word...

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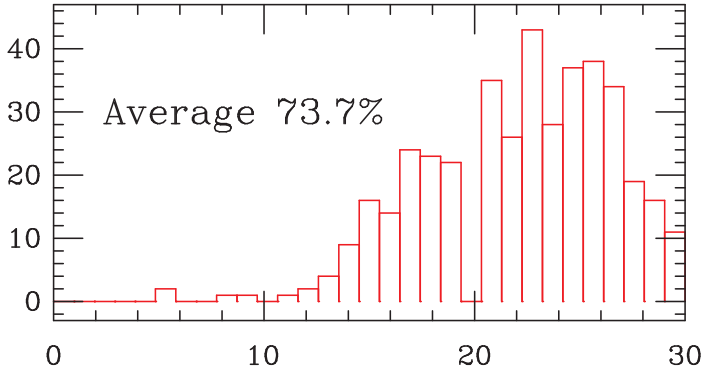

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(You should be proud of yourselves, too.)

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Plan for the rest of the semester

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- Part 2: Astromechanics: "Why does it move that way?"
- Part 3: Light: "How do we see the sky, and what can we learn from light?"
- Part 4: *Ad astra per aspera*: How do we get there, and what will we find?

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First: Science!

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They merged disciplines that had been separate since the time of the Greeks:

- Natural philosophy: "what is the truth of Nature?" (truth-seeking)
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- Truth in precision
- Synergy between truth-seeking and practical observation
- Synergy between theory and experiment
  - Theory: "Use things we've already observed to design a model"
  - Exp't: "Carefully choose observations to make to inform/test models"

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- Body of supporting evidence grows
- Continually seek to expand the *scope* of the model with more observations

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- What about gravity very close to big things?
  - Scope of Newton's gravity had to be modified
  - Newtonian gravity only right for small accelerations
  - Einstein: "I think I have a new model"
  - Newtonian gravity still correct within its scope

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- Scientific explanations are not anthropocentric – they don't give humans (or Earth) a special role

Scientific integrity

"But this long history of learning how not to fool ourselves–of having utter scientific integrity–is, I'm sorry to say, something that we haven't specifically included in any particular course that I know of. We just hope you've caught on by osmosis.
The first principle is that you must not fool yourself–and you are the easiest person to fool. So you have to be very careful about that. After you've not fooled yourself, it's easy not to fool other scientists. You just have to be honest in a conventional way after that.

...

I'm talking about a specific, extra type of integrity that is not lying, but bending over backwards to show how you are maybe wrong, that you ought to have when acting as a scientist.

...

One example of the principle is this: If you've made up your mind to test a theory, or you want to explain some idea, you should always decide to publish it whichever way it comes out. If we only publish results of a certain kind, we can make the argument look good. We must publish both kinds of results."

–Feynman, commencement address at Caltech, 1974

There's an entire discipline of mathematics designed to, in an objective way, examine what results mean: statistics.

But it's only as honest as the people wielding it: `https://xkcd.com/882/`

Science: a powerful tool

This synergistic enterprise has been behind a vast amount of progress for humanity in the last 350 years.

As with anything powerful, this process can be corrupted:

- Confirmation bias / placebo effect
- Ulterior motives: young-earth creationism, climate science, anything within an AU of politics
- Profit motive: vaccines causing autism
- Publication bias (jellybeans!)
- Artificially limited scope (some psych studies)

Science vs. pseudoscience

Often people adopt the trappings of science to give nonscientific ideas a veneer of validity. This is called "pseudoscience" – fake science.

Science

- Universal models
- Natural principles
- Testable predictions
- Not anthropocentric
- Replicable results
- Self-skepticism

Pseudoscience

- Singular events
- Supernatural explanations
- Untestable predictions
- Different rules for people
- Results defy replication
- Self-promotion

What would you like to talk about?

- Astrology
- Economics and integrity
- Ghosts and such
- Homeopathy vs. desensitization therapy
- Climate change
- Genetically-modified crops and statistics
- Vaccination
- ESP / telepathy
- Exterrestrial life
- Radioactive medicine
- Drug testing
- Medical marijuana
- Scientific integrity more broadly
- Something else...

"Our time is distinguished by wonderful achievements in the fields of scientific understanding and the technical application of those insights. Who would not be cheered by this? But let us not forget that human knowledge and skills alone cannot lead humanity to a happy and dignified life. Humanity has every reason to place the proclaimers of high moral standards and values above the discoverers of objective truth. What humanity owes to personalities like Buddha, Moses, and Jesus ranks for me higher than all the achievements of the enquiring and constructive mind. What these blessed men have given us we must guard and try to keep alive with all our strength if humanity is not to lose its dignity, the security of its existence, and its joy in living."

–Albert Einstein, 1937

"Tell your son to stop trying to fill your head with science for to fill your heart with love is enough!"

–Richard Feynman, 1981