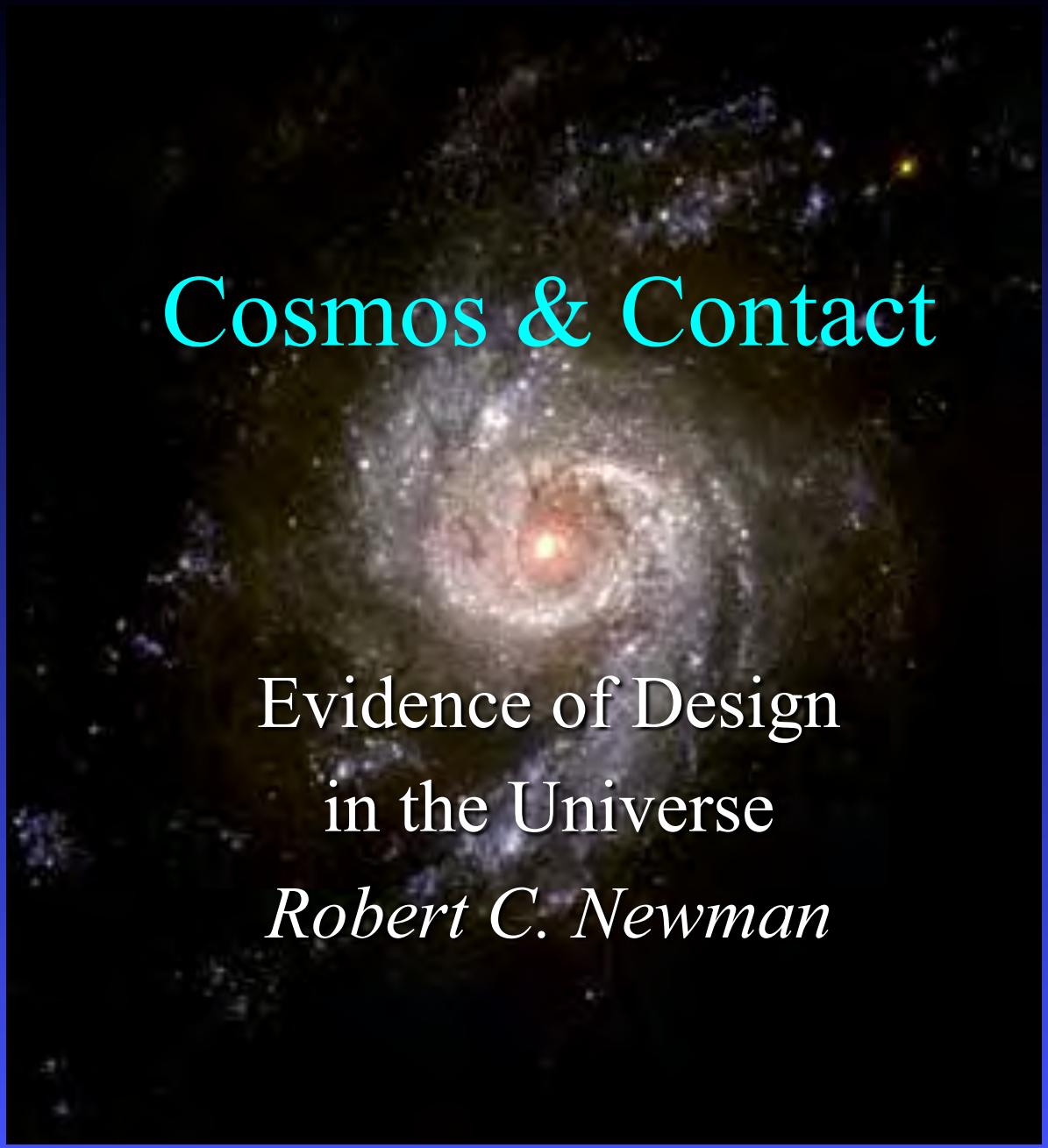

Cosmos & Contact

Evidence of Design in the Universe

Robert C. Newman

Carl Sagan's Opening Statement in his PBS Series *Cosmos*

The cosmos is all that is,

or ever was,

or ever will be.

Carl Sagan on Extra-Terrestrial Life

- Sagan doubts that God exists.
- Yet he believes life exists elsewhere in the universe, in spite of life's enormous complexity.
- He believes that (in some places) this life must include very advanced life forms.
- He believes such advanced life is common enough to be worth searching for.

The Search for ET Intelligence

- Many besides Sagan have such dreams.
- Perhaps (they think) we can contact such life.
- Perhaps these beings have solved the difficult and dangerous problems we face today.
- The most likely way to contact an advanced civilization would be through its radio signals.

The Plot of *Contact*

- Ellie Arroway, astrophysicist, devotes her professional career to searching for ETI.
- Despite many setbacks, the long-awaited message finally comes, a strong signal from Vega.
- The signal is seen to be more than radio noise by the presence of prime numbers, indicating an intelligent source.

The Plot of *Contact*

- Eventually, a more complex message is found in the signal, instructions to build a device to transport a human to Vega.
- After several twists in the plot, Ellie winds up going to Vega on the transporter.
- Our clip picks up as she arrives …

Sagan on Recognizing an ET Message

- Strong signal.
  - Detectible by multiple radiotelescopes.
- Decisive against chance origin.
  - A few dozen prime numbers sufficient.
- The whole message to build the transport machine is about fifty thousand pages.

How the Book Ends

- Ellie discovers a message in the digits of pi.
  - Found in base 11 arithmetic
  - A square picture made up of 0s and 1s
  - The picture: a circle of 1s in a field of 0s
- Simple message, but high statistical significance
- The universe was made on purpose, the circle said.

How the Book Ends

359X21086652790X4312567089243

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The film doesn't end this way…

- No message from God in the film!
- Why not?
  - Did Hollywood veto this ending?
  - Did Sagan back away from "the precipice of theism" in his last years?
- Don't know
  - Sagan's novel *Contact* is more open to theism than his last book *Demon Haunted World* is.

Could God Do Something Like This?

- Could God put a message in the digits of pi?
- Seems doubtful God could put a message there:
  - Pi is built into the structure of logic and so not variable.
  - God cannot do what is contradictory.
- Could God send us some other message?
  - Why not?

Where Might God Put Such a Message?

- He could put it in something He has created.
- Do we have any candidates for such a medium and such a message?
- Yes, several. Here we consider three:
  - The universe itself
  - Our place in the universe
  - Living things

A Message in the Universe

- Seen in its "fine-tuning"
- Some bibliography:
  - L.J. Henderson, *The Fitness of the Environment*
  - Paul Davies, *The Accidental Universe*
  - John Barrow & Frank Tipler, *The Anthropic Cosmological Principle*
  - Hugh Ross, *The Creator & the Cosmos*
  - Michael Denton, *Nature's Destiny*

Fine-Tuning the Basic Forces

- Strong Force
  - short range, strength 1
- Electromagnetism
  - long range, strength 1/100
- Weak Force
  - very short, strength 1/100,000
- Gravity
  - long range, strength $1/10^{39}$
- As divergent in strength as these forces are, very slight changes in any would be disastrous.

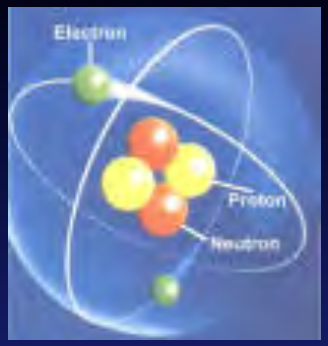
The Strong Force

- Holds nucleus together.
- 50% weaker, no stable elements but H
- 5% weaker, no deuterium, stars won't burn
- 5% stronger, diproton stable, stars explode
- The strong force is tuned to ±5% on the basis of these considerations alone.

The Weak Force

- Holds neutron together.
  - Neutron decay: half-life 13 minutes
  - Neutron Proton + Electron + Antineutrino
- Few % weaker, then few n, little He, few heavy elements; even these stay trapped in stars.
- Few % stronger, then many n, too much He, too many heavy elements; but these, too, stay trapped in stars.
- The weak force is tuned to a few percent.

Electromagnetism



- Holds atom together, also molecules.
- Both repulsive & attractive, due to existence of positive & negative charges.
- + and – charges must be almost exactly equal in number, to better than one part in 10^{40}.
- Yet protons (+) and electrons (-) drastically different in mass, and froze out at quite different times in the early universe.
- If not for this equality, e-m would dominate gravity, so no galaxies, no stars, no planets.
- E-m is tuned to one part in 10^{40}.

Gravity

- Dominant force on astronomical size scale.
- Need very close balance of gravity and cosmic expansion for stable universe.
  - If gravity weaker by 1 in 10^{60}, universe expands too quickly, no galaxies or stars formed.
  - If gravity stronger by 1 in 10^{60}, universe collapses without forming galaxies or stars.
- Gravity is fine-tuned to 1 part in 10^{60}.

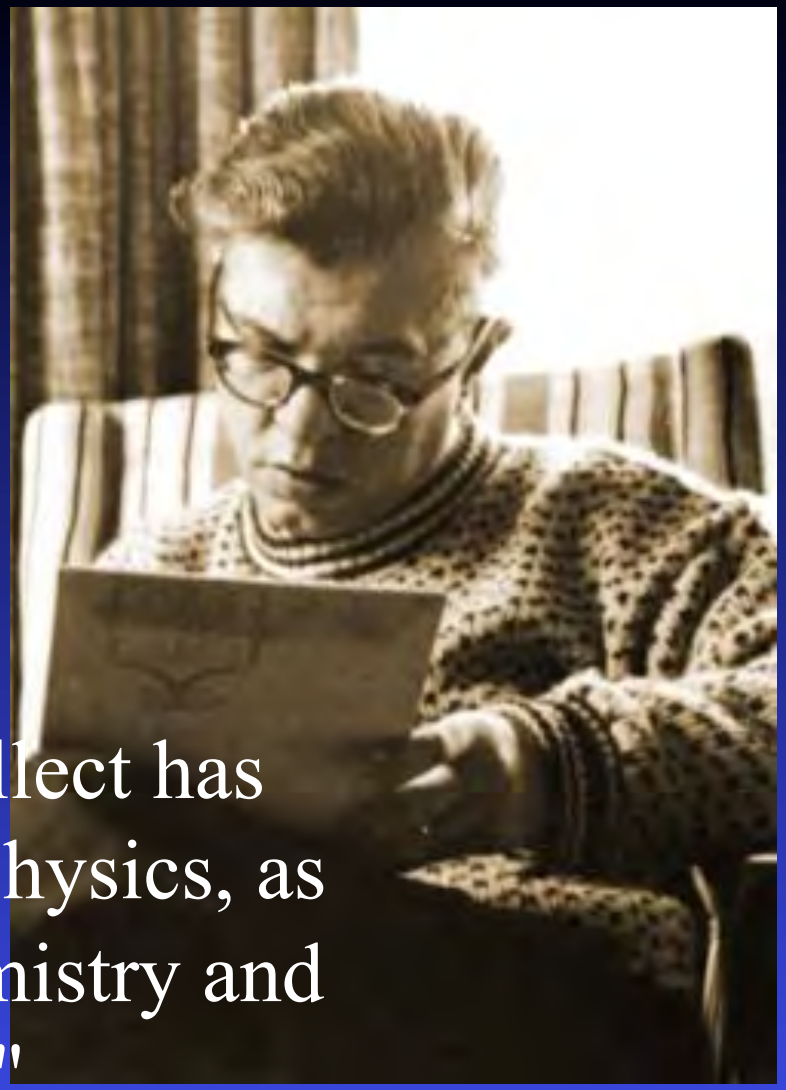
Summary on Fine-Tuning

- Combining these cases gives fine-tuning of better than one part in 10^{100}.
- How big is 10^{100}?
  - 1 with 100 zeroes after it.
  - There are estimated to be some 10^{80} elementary particles in our universe.
  - So we need to 10^{20} universes to get 10^{100} particles!
  - Imagine the chances of randomly picking one marked particle from all these universes!

Summary on Fine-Tuning

- Fine-tuning of universe is about 1 part in 10^{100} for the cases we have examined.
- Hugh Ross, in *The Creator & the Cosmos*, lists 22 more items besides these four.
- Do we really have any evidence for even 10^{100} universes to make this likely merely by chance?
- The universe looks designed.
- It seems to be sending us a message to this effect.

Sir Fred Hoyle on Fine-Tuning



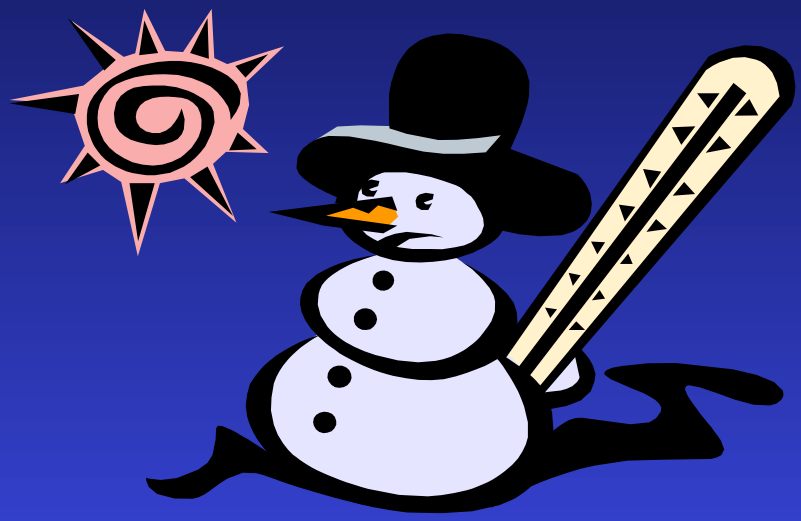
"… a superintellect has monkeyed with physics, as well as with chemistry and biology."

Our Place in the Universe

- Besides fine-tuning of basic forces, our particular location in the universe is quite special, a matter of many features being just right.
- In his 1995 edition, Ross lists over 33 of these drawn from the scientific literature.
- Let's look at a few of these in this presentation.

The Right Planet: Temperature

- Varies from place to place on Earth, but:
  - Few above boiling
  - Some below freezing
- Contrast Venus, about 900 ^{o}F (500 ^{o}C).
- Contrast Mars, barely gets above freezing in midsummer at the equator.
- Earth is warm enough for water to be liquid, cool enough not to destroy biomolecules.



The Right Planet: Water

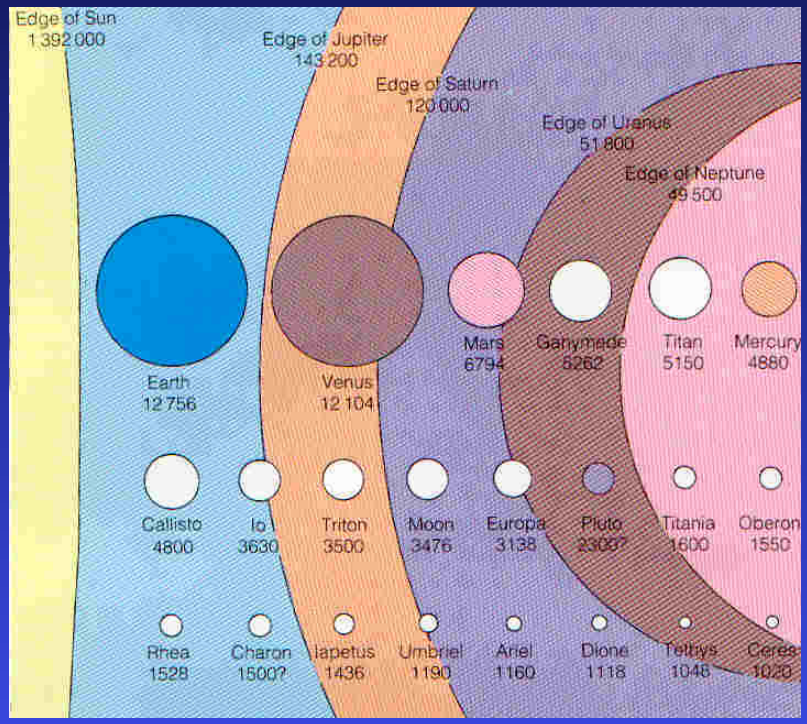
- Much water is needed to support life, though a few organisms have techniques to conserve it and can live in arid regions.
- Water on Venus and Mars is infinitesimal by comparison.
- Earth's water is also concentrated at the surface.

The Right Planet: Atmosphere

- Balance of oxygen and "inert" gases:
  - Few % less oxygen and animals can't breathe
  - Few % more oxygen and plants burn up
- Mars and Venus have virtually no free oxygen.

The Right Planet: Mass

- If Earth were ¼ as massive, atmospheric pressure would be too low for life.
- If Earth were twice as massive, atmospheric pressure would be too high, producing a greenhouse effect and killing all life.



The Right Moon: Size & Distance

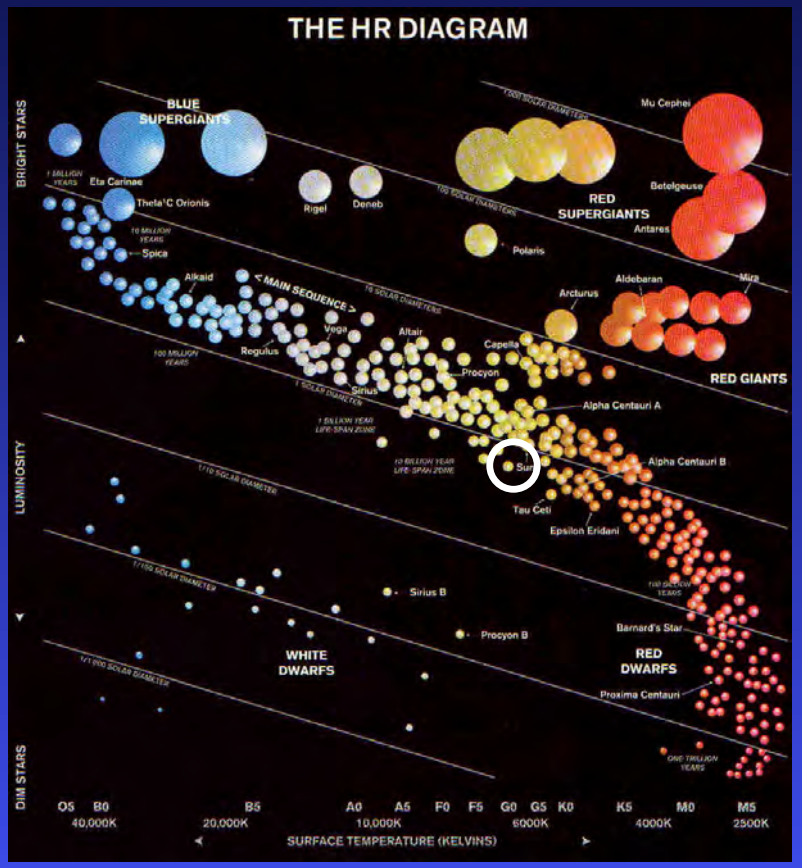
- Our Moon is unique in the Solar System, by far the largest compared with its planet.
- If it were smaller (or further away), Earth's climate would be unstable, tides too small for mixing.
- If it were larger (or closer), tidal effects on Earth's rotation, ocean & atmosphere too large.

The Right Moon & Earth's Crust

- If Earth's crust thicker, it would eat up the atmospheric oxygen.
- If Earth's crust thinner, too much volcanism and plate movement.
- The Moon apparently formed from the Earth's crust, when we were struck by a Mars-sized planet, a very fluky event!

The Right Sun: Character

- Mass in right range:
  - Heavier – luminosity changes too quickly
  - Lighter – life zone too narrow, tides too large
- Temperature (color) in right range:
  - Redder – insufficient photosynthesis
  - Bluer – ditto
- The Sun's radiation is right where our atmosphere is transparent.

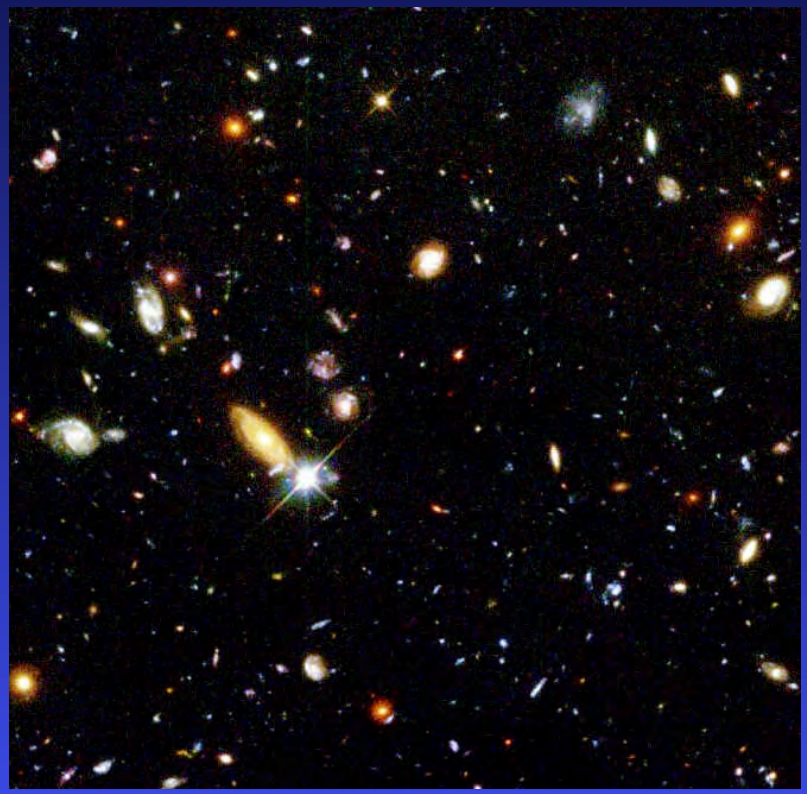


The Right Sun: Location

- Distance from center of galaxy:
  - Closer – gravity, radiation disruptive
  - Further – too few heavy elements
- Right for supernovae:
  - More or closer – exterminate life
  - Less or further – too few heavy elements
- Right number of stars in system, namely one!

The Right Galaxy

- Our galaxy is a spiral, which produces stars over much of its history.
- Not an elliptical, where star formation ends before there are many heavy elements.
- Not an irregular, where radiation events would have destroyed life.



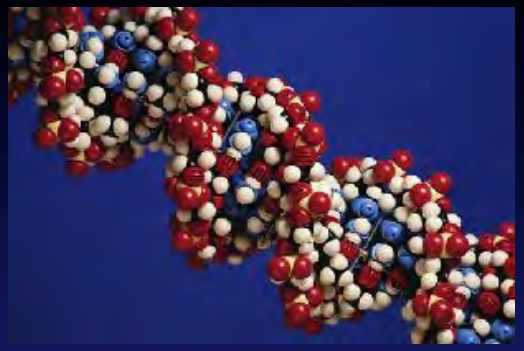
Our Place in the Universe

- Right Planet:
  - Temperature, Water, Atmosphere, Mass
- Right Moon:
  - Size, Distance, Earth's Crust
- Right Sun:
  - Character, Location
- Right Galaxy

Our Place in the Universe

- Ross calculates the probability of accidentally getting his 33 items in the right range as 1 chance in 10^{53}.
- What does this mean for the chances of finding an earth-like planet in our universe?
  - Surely not more than 10 planets per star.
  - If so, only 10^{24} planets in the Hubble volume.
  - Thus only 1 chance in 10^{29} of getting even one such planet in our universe!
- Our place in the universe appears to be telling us something!

Living Things



- Living things are by far the most complex objects we have yet found in our universe.
- Sagan says of the *E. coli* bacterium:
  - Information content = 10^{12} bits.
  - Equivalent to 100 million pages of the *Encyclopaedia Britannica.*
- Humans have trillions of cells, each more complex than those of *E. coli.*

Fred Hoyle on Living Things

"The chance that higher life forms might have emerged [accidentally] is comparable with the chance that a tornado sweeping through a junk-yard might assemble a Boeing 747 from the materials therein."

Sagan on Recognizing an ET Message

- Strong signal.
  - Detected by several radiotelescopes.
- Decisive against chance.
  - A few dozen prime numbers sufficient.
- The whole message to build the transport machine is about fifty thousand pages.

Recognizing the Life Message

- Strong signal.
  - Seen in the DNA of all living things.
- Decisive against chance.
  - The information content is beyond the probabilistic resources of the universe.
- The whole message to build an *E. coli* bacterium is about 100 million pages.

Adjusting One's Worldview

- If Sagan was really open to the universe;
- If he was really willing to consider the supernatural;
- Why didn't he respond to this sort of evidence?
- Why did he draw back from "the precipice of theism"?
- Do you need to adjust your worldview?