[27] Life in the Universe 2 (12/7/17)

Upcoming Items

- Final discussion section tomorrow: review, driven entirely by your questions
- Second review: Monday, Dec 11, 6-8 PM
- Last day for tutoring: Monday, Dec 11
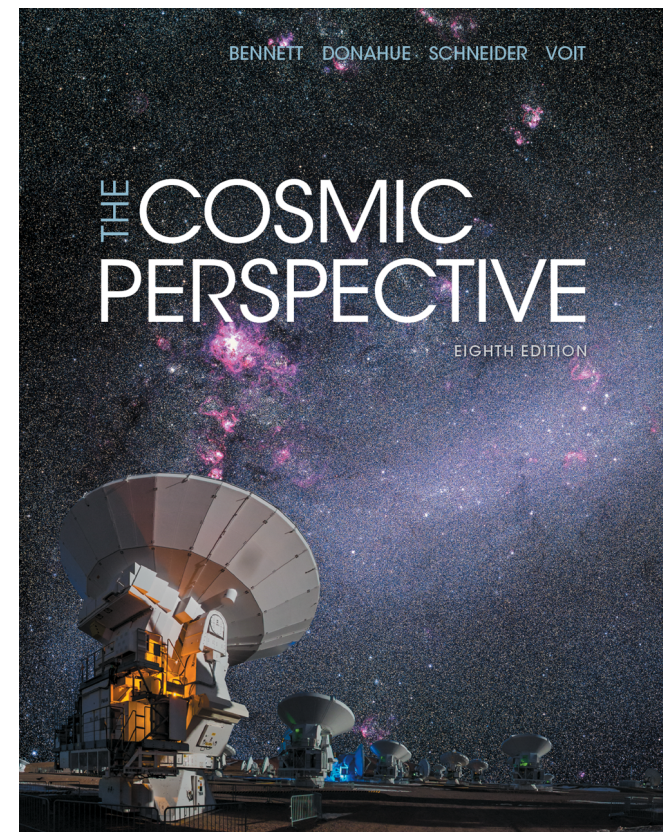- FINAL EXAM on Wednesday, Dec 13 from 8-10 am in this room.

Maybe they're friendly!

LEARNING GOALS

Chapter 24

For this class, you should be able to…

… *Discuss some of the challenges facing an intelligent species*

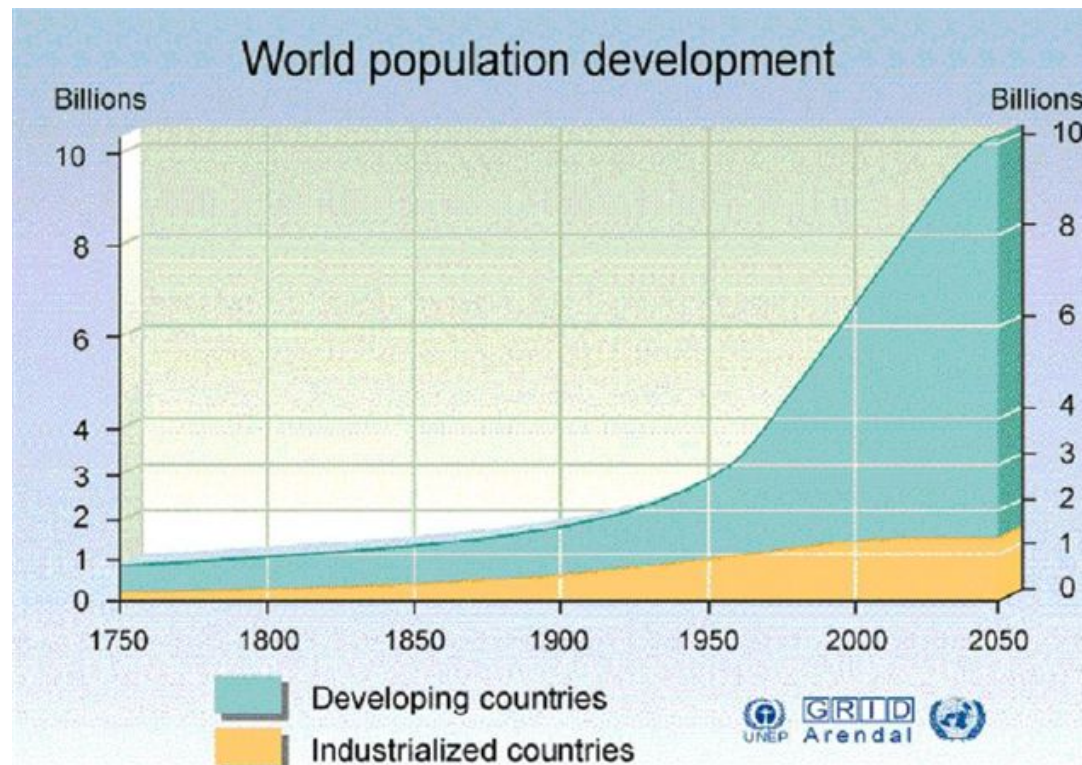… *explain some of the challenges presented by interstellar travel.*

Any astro questions?

Last Debate!

- Are there currently any interstellar civilizations in the Milky Way?

Exponential Growth

- Now, future with humans
- Critical fact: exponential growth of population will always dominate
- 1.2% annual growth? By year 2800, 17 trillion people

http://japanfocus.org/images/UserFiles/Image/2456.asahi.jasglobalcontributor/World%20Population%20Growth%20to%202050.JPG

A Comment: Limits on Growth

- Population growth is a tremendous long-term problem for humanity
- And yet, when you point this out to people, they often shrug it off; new resources will always be available, or maybe we can leave this planet and find more
- In addition, it is ridiculous to imagine unlimited growth of population, so something will intervene
- What is wrong with these perspectives?

How many civilizations are out there?
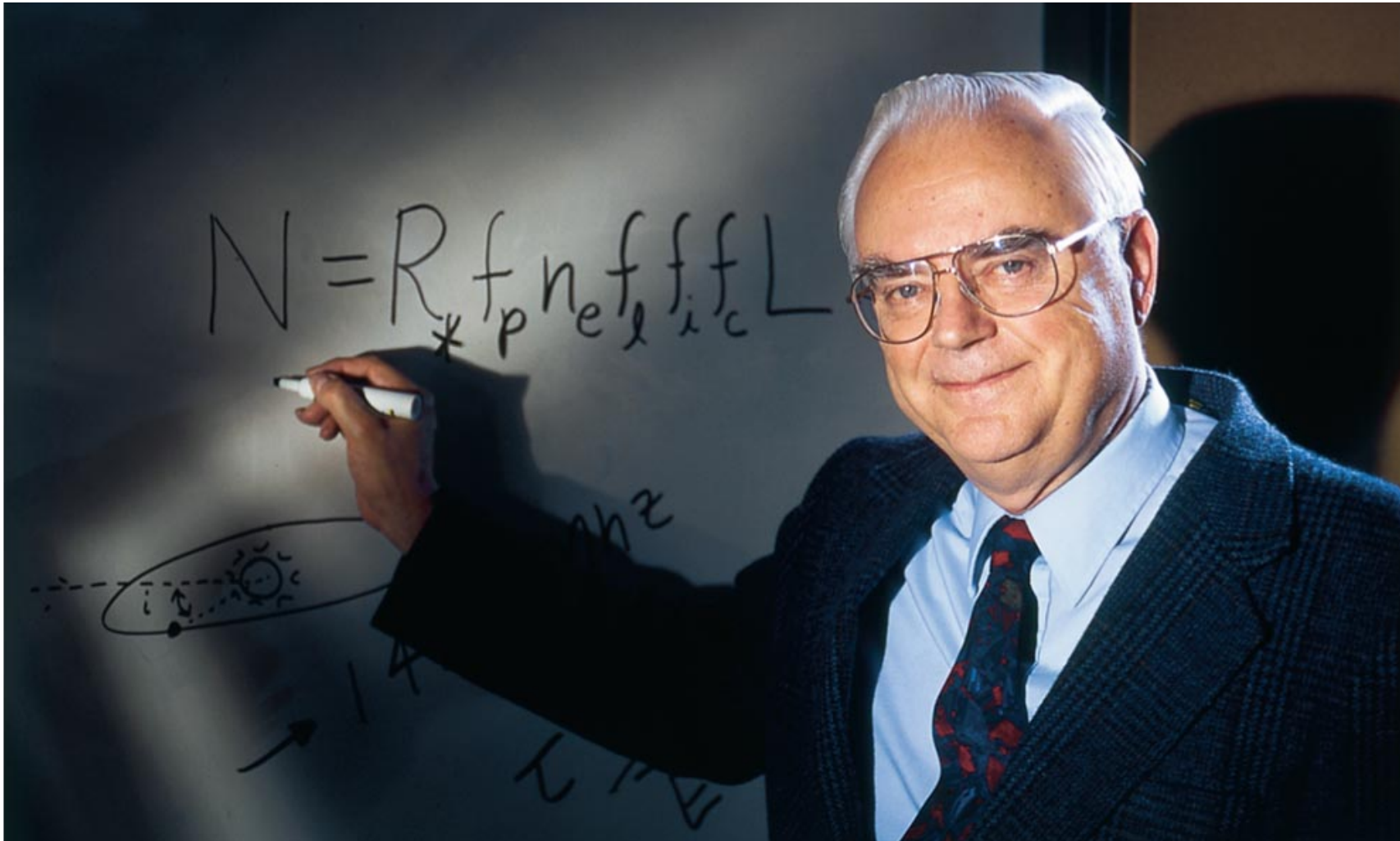
The Drake Equation

Number of civilizations with whom we could potentially communicate

$$= N_{HP} \times f_{life} \times f_{civ} \times f_{now}$$

N_{HP} = total number of habitable planets in galaxy.

f_{life} = fraction of habitable planets with life.

f_{civ} = fraction of life-bearing planets with civilization at *some* time.

f_{now} = fraction of civilizations around *now*.

Note: there are many other versions of the Drake equation!
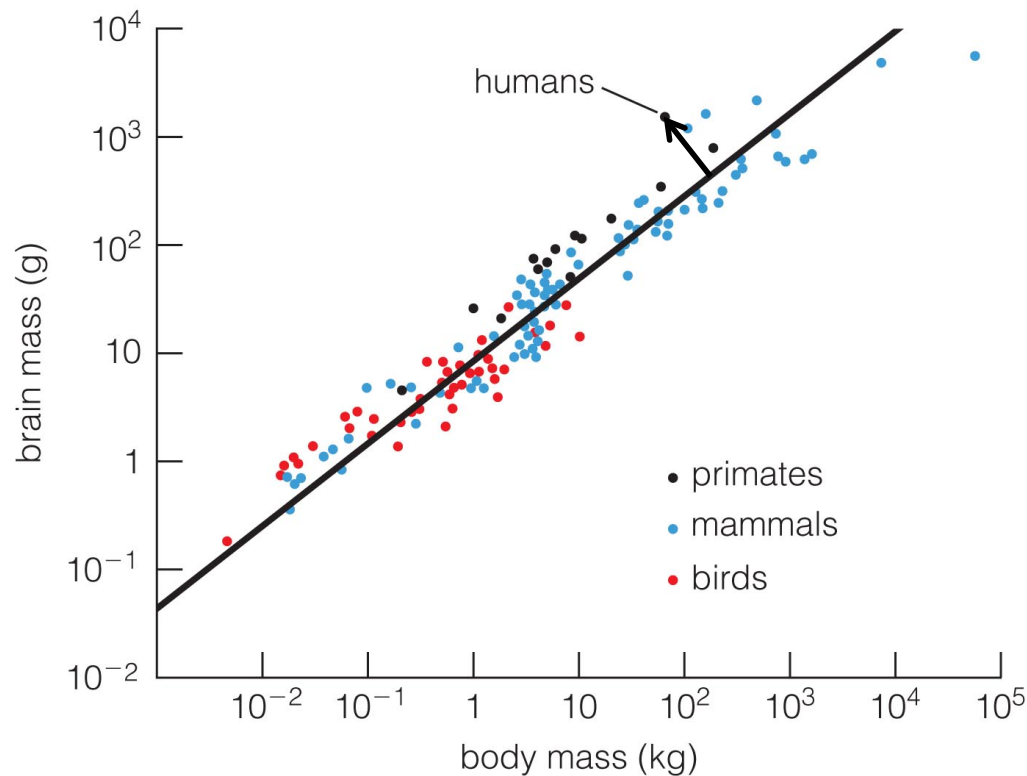
We do not know the values for the Drake equation

N_{HP}: probably billions.

f_{life}: ??? hard to say (near 0 or near 1).

f_{civ}: ??? (took 4 billion years on Earth).

f_{now}: ??? (depends on whether civilizations can survive long-term).
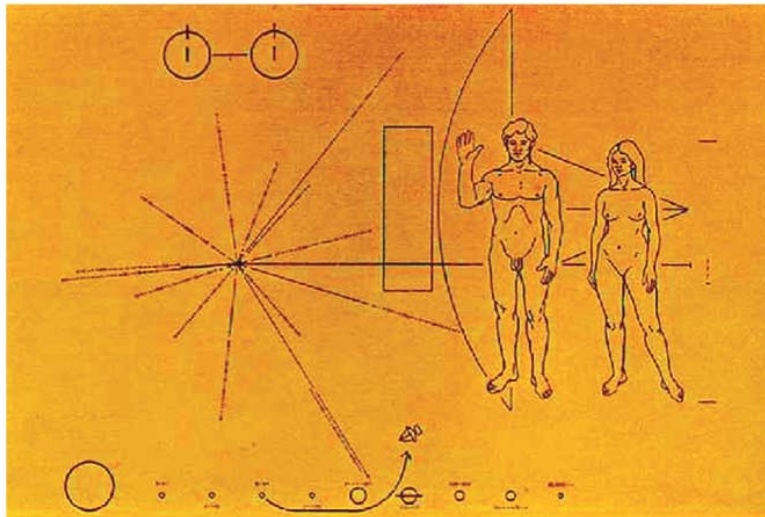
Are we "off the chart" smart?

- Humans have comparatively large brains.

- Does that mean our level of intelligence is improbably high?

How difficult is interstellar travel?

Current Spacecraft

- Current spacecraft travel at <$1/10,000c$; 100,000 years to the nearest stars.
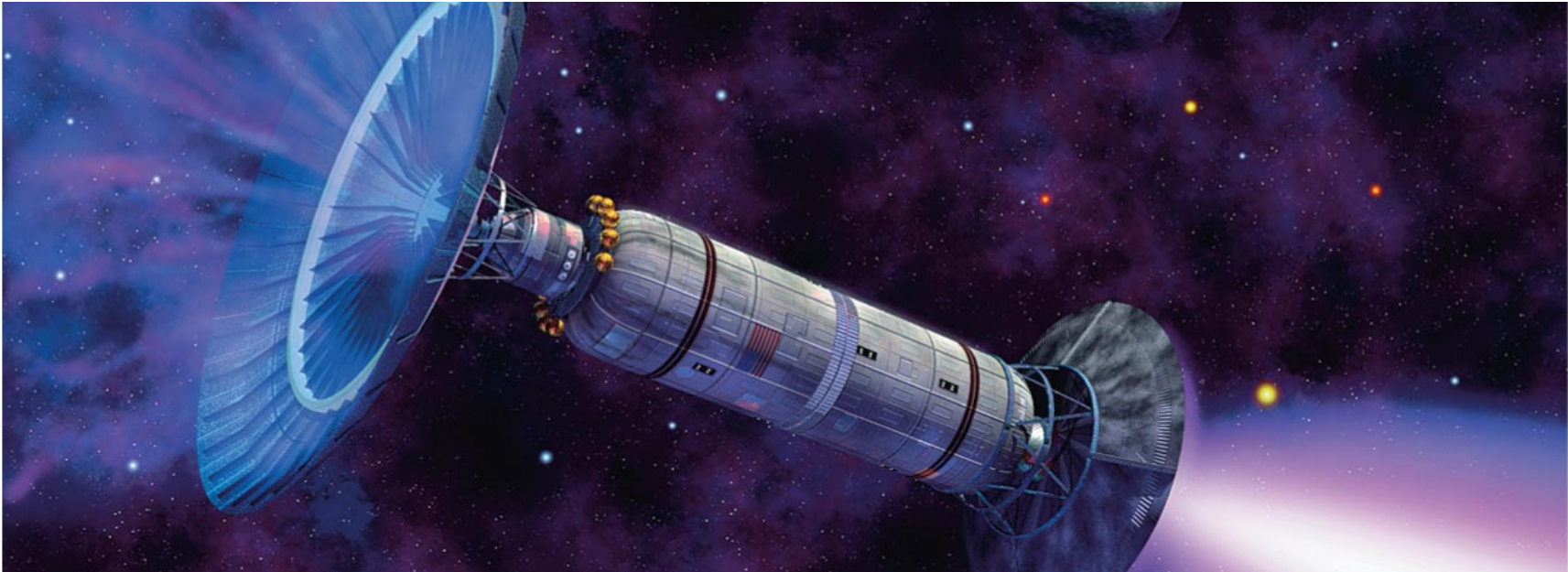

Pioneer plaque

Voyager record

Difficulties of Interstellar Travel

- Far more efficient engines are needed.
- Energy requirements are enormous.
- Ordinary interstellar particles become like cosmic rays.
- Social complications of time dilation.

Suspended Animation

- Keep people alive, but at a low metabolic rate
- Possibly in cryogenic sleep
- Might wake people up in rotation to deal with critical issues
- Advantage: fewer resources
- Disadvantage: handling of emergencies?

Frozen Embryos

- Or eggs
- Easier to keep suspended than full adult
- Advantage: negligible resources needed, and could do same thing with other plants and animals
- Disadvantage: would need completely automated ship, and robot parents upon landing

http://www.projectrho.com/rocket/womb01.jpg
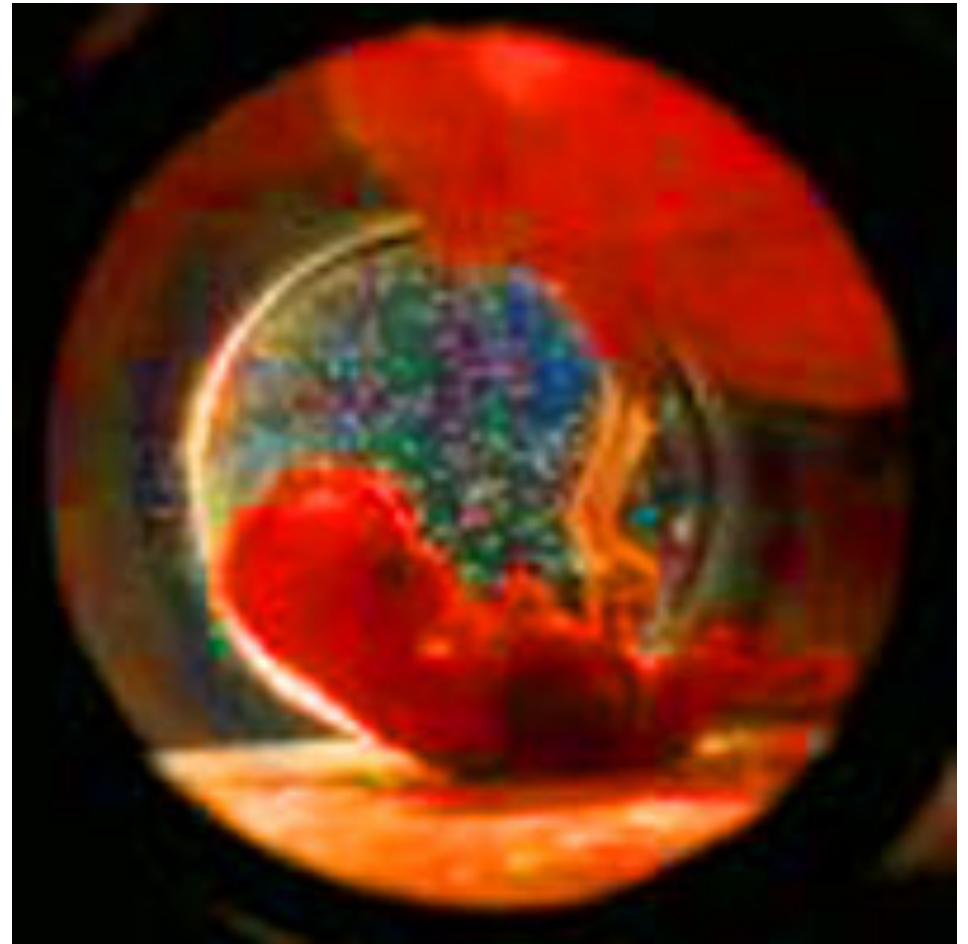
Store Humans as DNA?

- Why not go all the way?
- Human DNA has about 3 billion base pairs, at 1/4 byte each
- Current computers can easily store 1 Terabyte
  >1000 human DNAs!
- If also send frozen nutrients, could grow
- Need to be careful about persistence of computer memory

http://files.turbosquid.com

Where Are the Aliens?

- Takes a long time to travel between stars, but we have plenty of time
- At 100,000 years per parsec, we could travel the 10,000 parsecs to the center of our galaxy in 1 billion years
- The galaxy has existed for >10 billion years
- So where are they?

Could the aliens be here?

- I debated about whether I should tell you the following story, but I think we've developed a good level of trust, so here goes...

The Burden of Proof

- Suppose I claim to have seen an alien
- Is it up to you to disprove me?
- No!
- Carl Sagan: "Extraordinary claims require extraordinary proof"
- What does this mean in practice?

First Claim

- Suppose I told you that yesterday I saw a friend walking down the street
- Would you believe me? If not, what level of proof would you require?

Second Claim

- Now suppose I told you that the other day I saw a 100-foot tall cyclops walking down the street

- Would you believe me? If not, what level of proof would you require?

http://bearah718.tripod.com/sitebuildercontent/sitebuilderpictures/cyclops.jpg

Fermi's Paradox

- Plausible arguments suggest that civilizations should be common. For example, even if only 1 in 1 million stars gets a civilization at some time $\Rightarrow$ 100,000 civilizations in our galaxy alone.

- So why we haven't we detected them?

Possible solutions to the paradox

1. We are alone: life/civilization is much rarer than we might have guessed.

   - Our own planet/civilization looks all the more precious…

Possible solutions to the paradox

2. Civilizations are common, but interstellar travel is not because…

- Interstellar travel is more difficult than we think.
- The desire to explore is rare.
- Civilizations destroy themselves before achieving interstellar travel.

These are all possibilities, but not very appealing…

Possible solutions to the paradox

3. There IS a galactic civilization…

   … and some day we'll meet them.