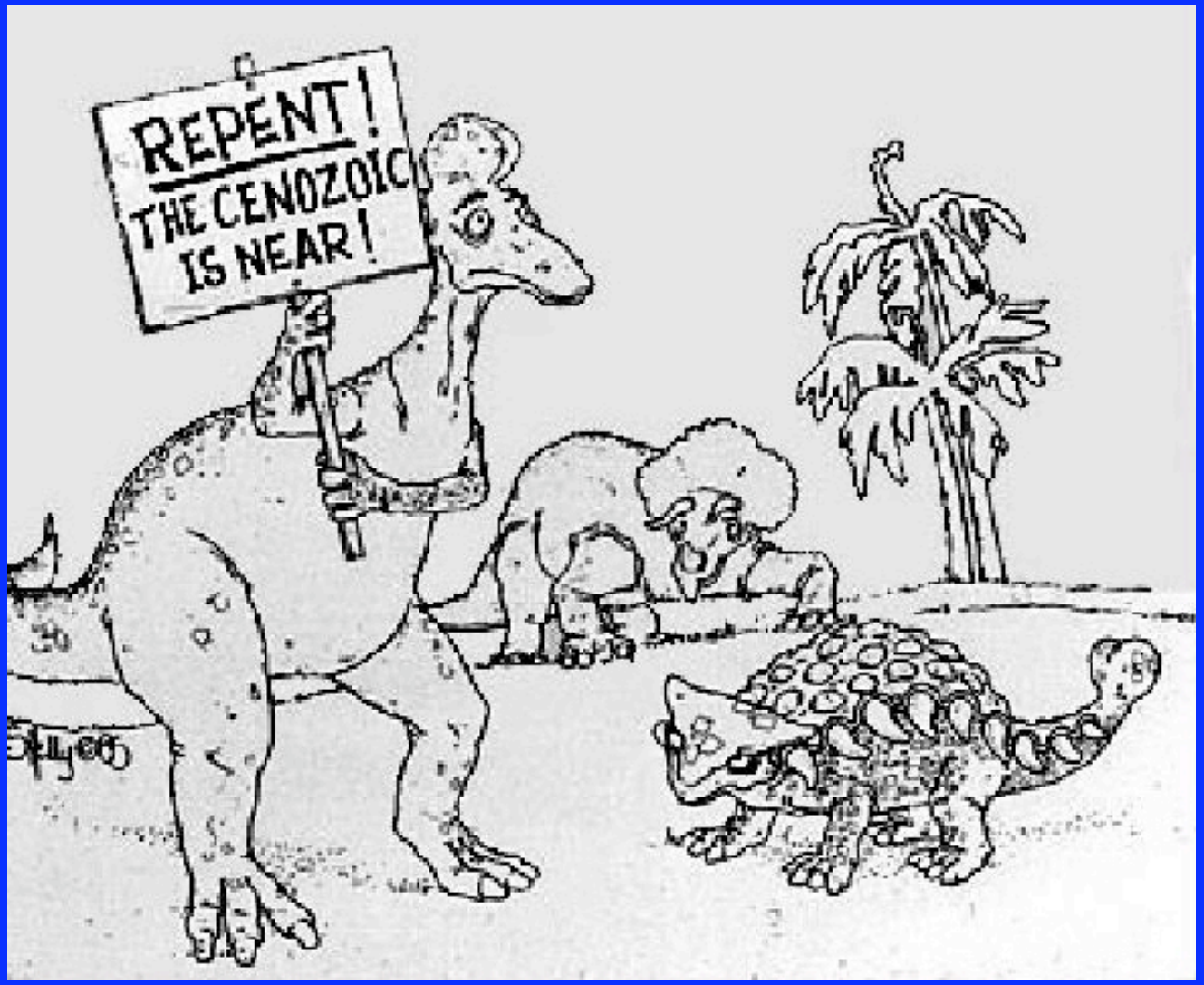
ASTR 380
Mass Extinctions



http://img118.imageshack.us/img118/9459/7113813718681904oel3.jpg

Outline

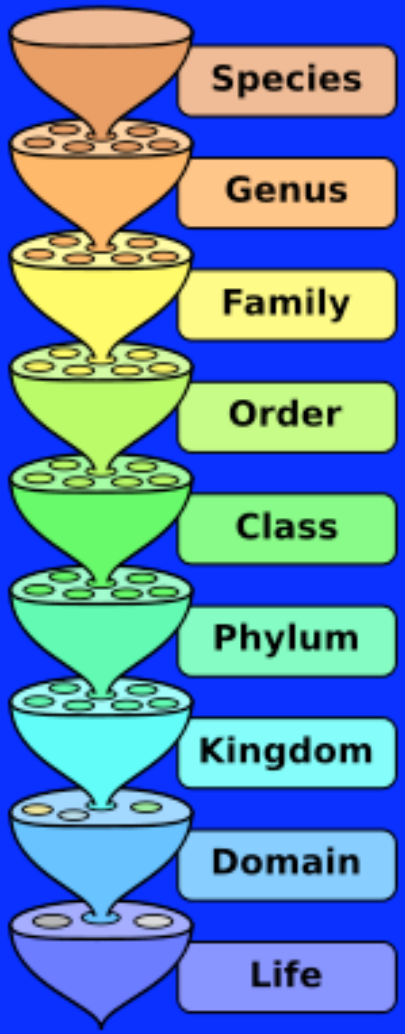
- What is a mass extinction?
- Famous mass extinctions
- The good and bad

Midterm Tues, Oct 13

- On everything through today's class
  Both sets of notes, lectures, HW, book
- Format similar to homework
  But no notes or book allowed
  Bring calculator, pens; we'll supply paper
- Review session tonight, this room 7 PM
  Led by your TA DJ
  Entirely driven by your questions, discussion

Taxonomic Classifications

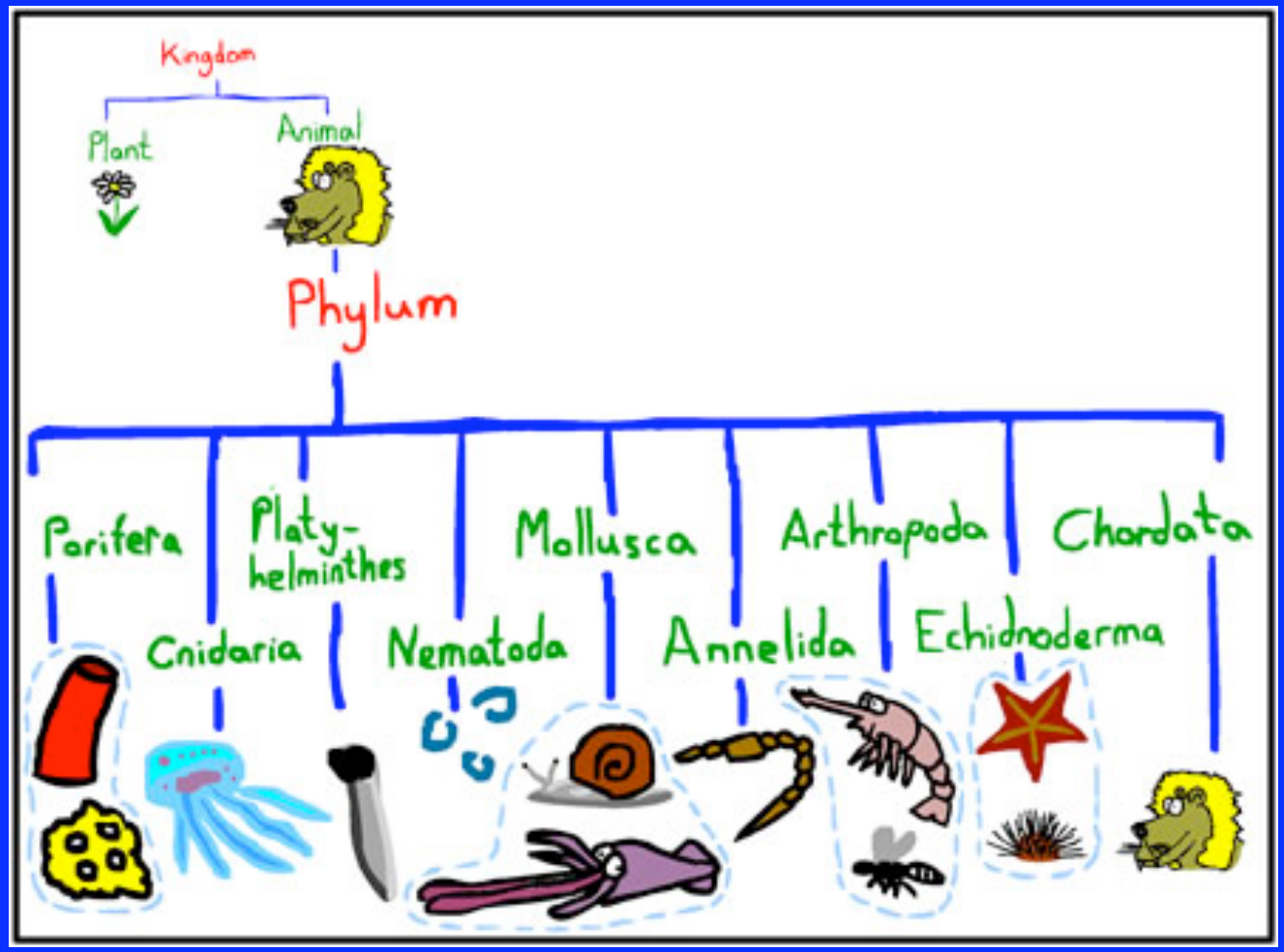
- To set stage: life is divided up into categories
- Members of same species can produce viable offspring
- Genera (plural of genus) are groups of related species, etc.



http://upload.wikimedia.org/wikipedia/commons/thumb/5/5f/Biological_classification_L_Pengo.svg/150px-Biological_classification_L_Pengo.svg.png

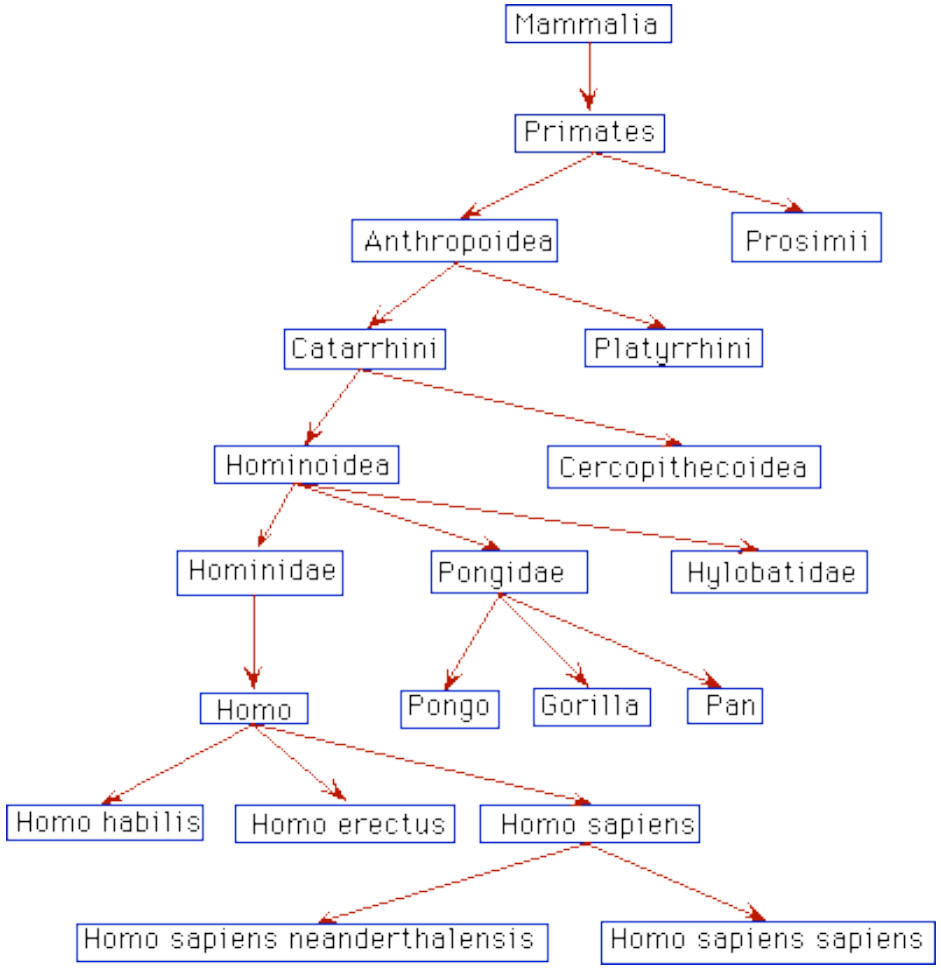
Example: Animals

Not all listed; most are “worms”!



http://www.sharky-jones.com/Sharkyjones/Artwork/taxonomy%20artwork/Phylum1.jpg

Example: Human Taxonomy



At a higher level: we are animals, chordates, and mammals.

Many living relatives. Closest are chimps

http://www.ecotao.com/holism/primatetaxon.gif

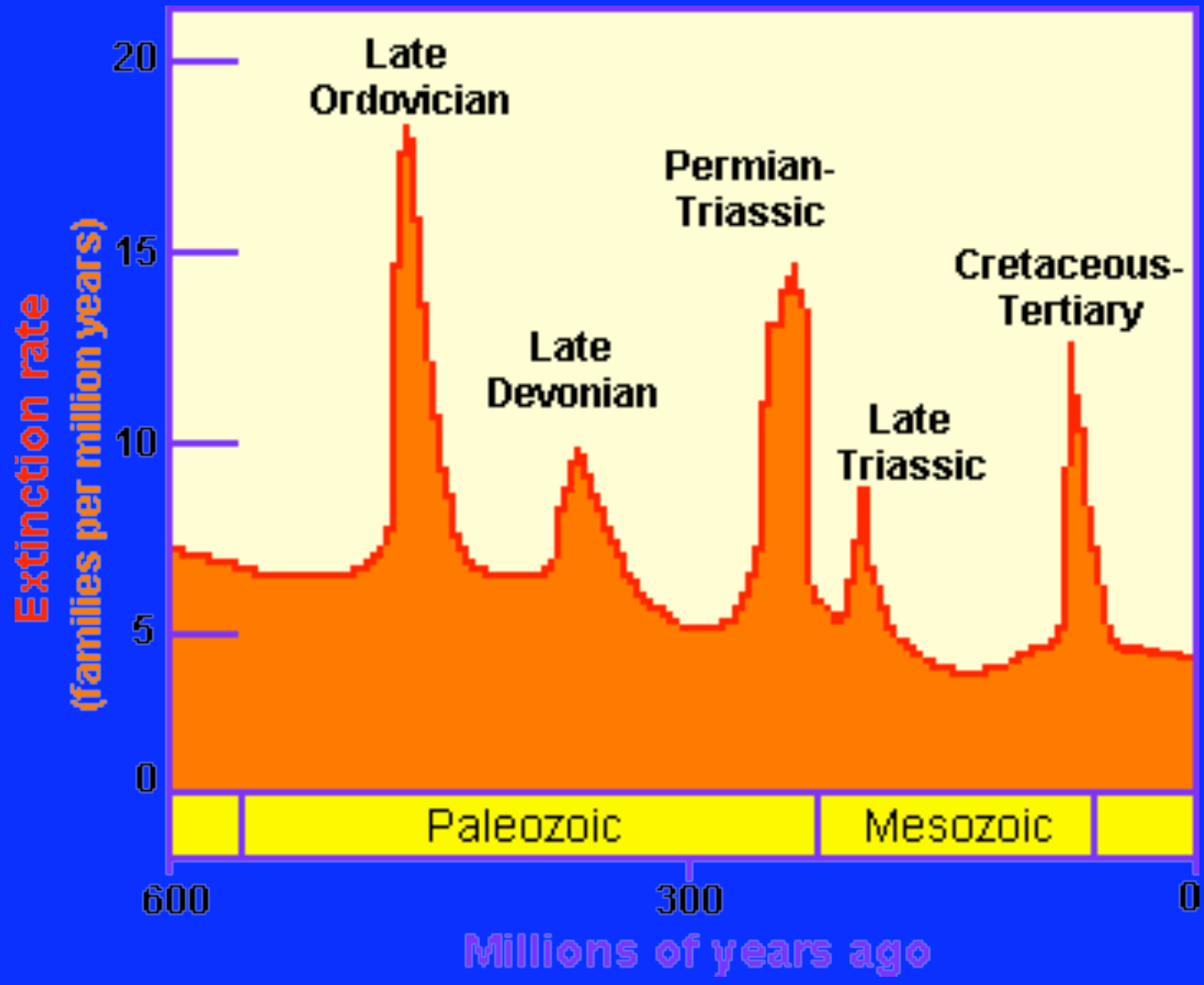
The Point for Extinctions

- Individuals die constantly
- Species can be wiped out if they are outcompeted or their ecological niche is eliminated
- For genus to go extinct, all species in it must
- For family, all genera must go extinct
  E.g., >40,000 species of ground beetle family!

What is a Mass Extinction?

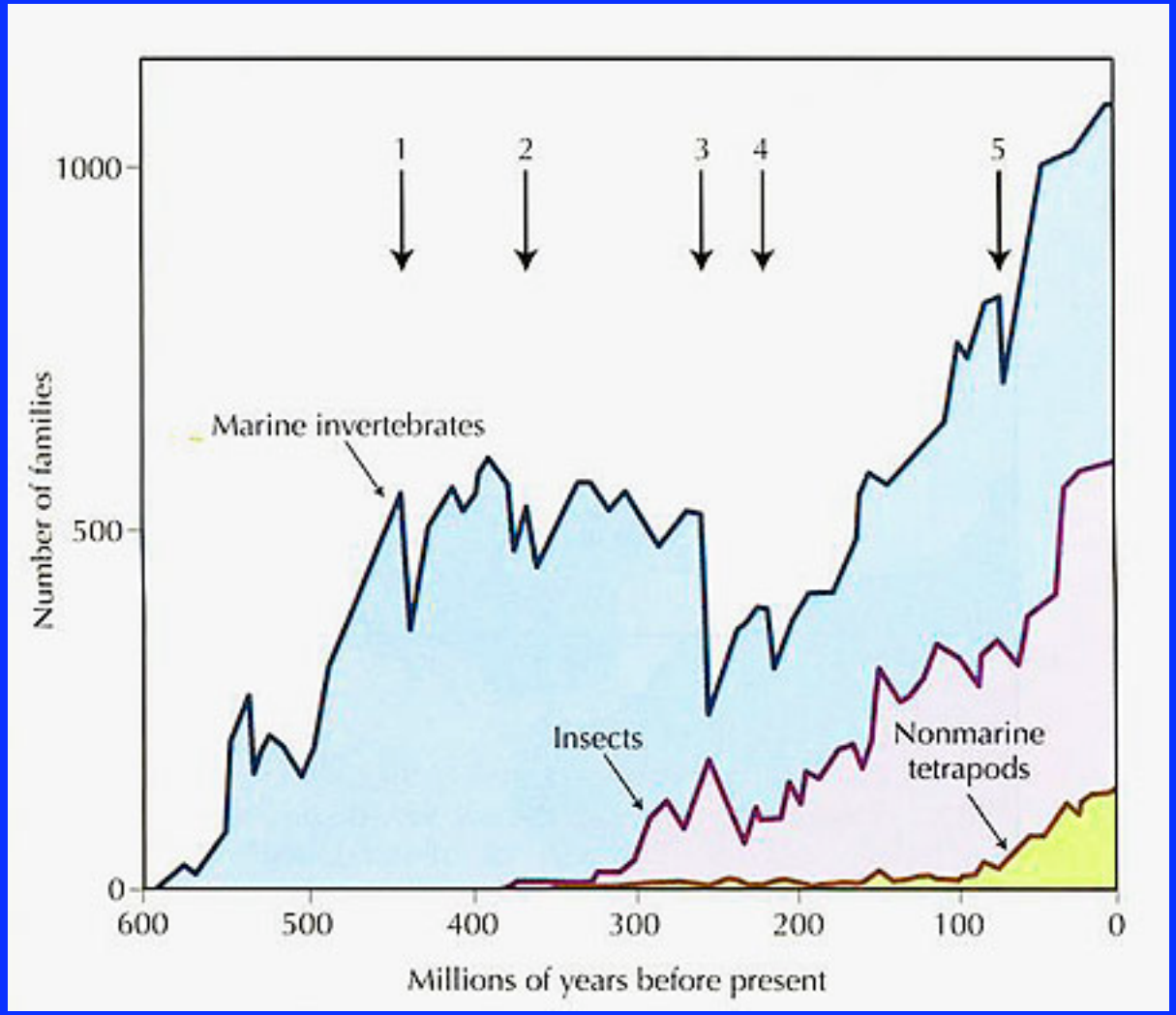
- We mean a sharp increase in the number of species/genus/family extinctions in a short time
- In last 540 million years (since we've had complex life), have had five in which >50% of animal species went extinct
  The "Big Five" extinctions

What is a Mass Extinction?



http://ircamera.as.arizona.edu/NatSci102/NatSci102/images/extinct.gif

Another Look: Number of Families



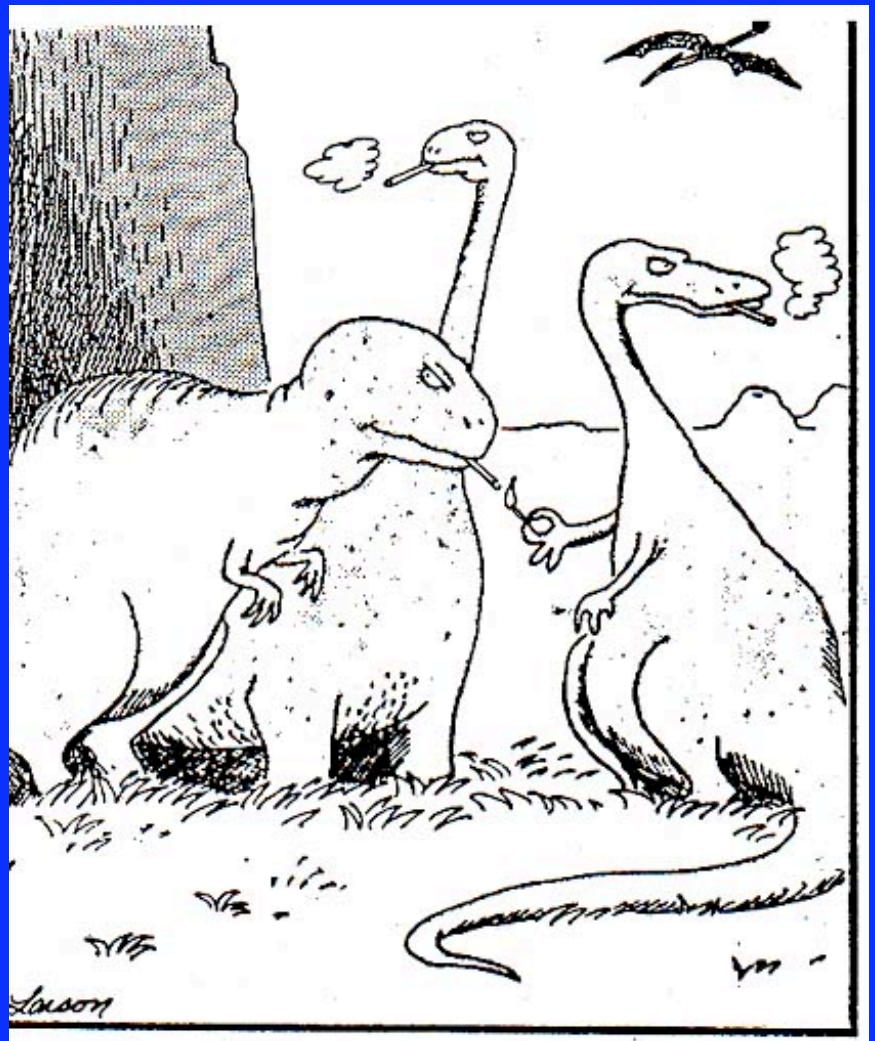
http://home.planet.nl/~gkorthof/images/extinctions.jpg

Difficulties

- Establish extinction by noting that a species appears below, but not above, a rock layer
- But fossils are incomplete
  Can easily have "gap" because of this
  Makes duration of event tough to say
- For some organisms, instant extinction could look like millions of years in rock!
  But mass extinctions need not be catastrophic
- Also, there are few beds of rock that cover the whole period seamlessly

What Killed the Dinosaurs?

- More generally, this is the K-T extinction ~65 million years ago
- Dinos had dominated land for 160 Myr
- Mammals too quick? Don't be silly!
- Other explanations?



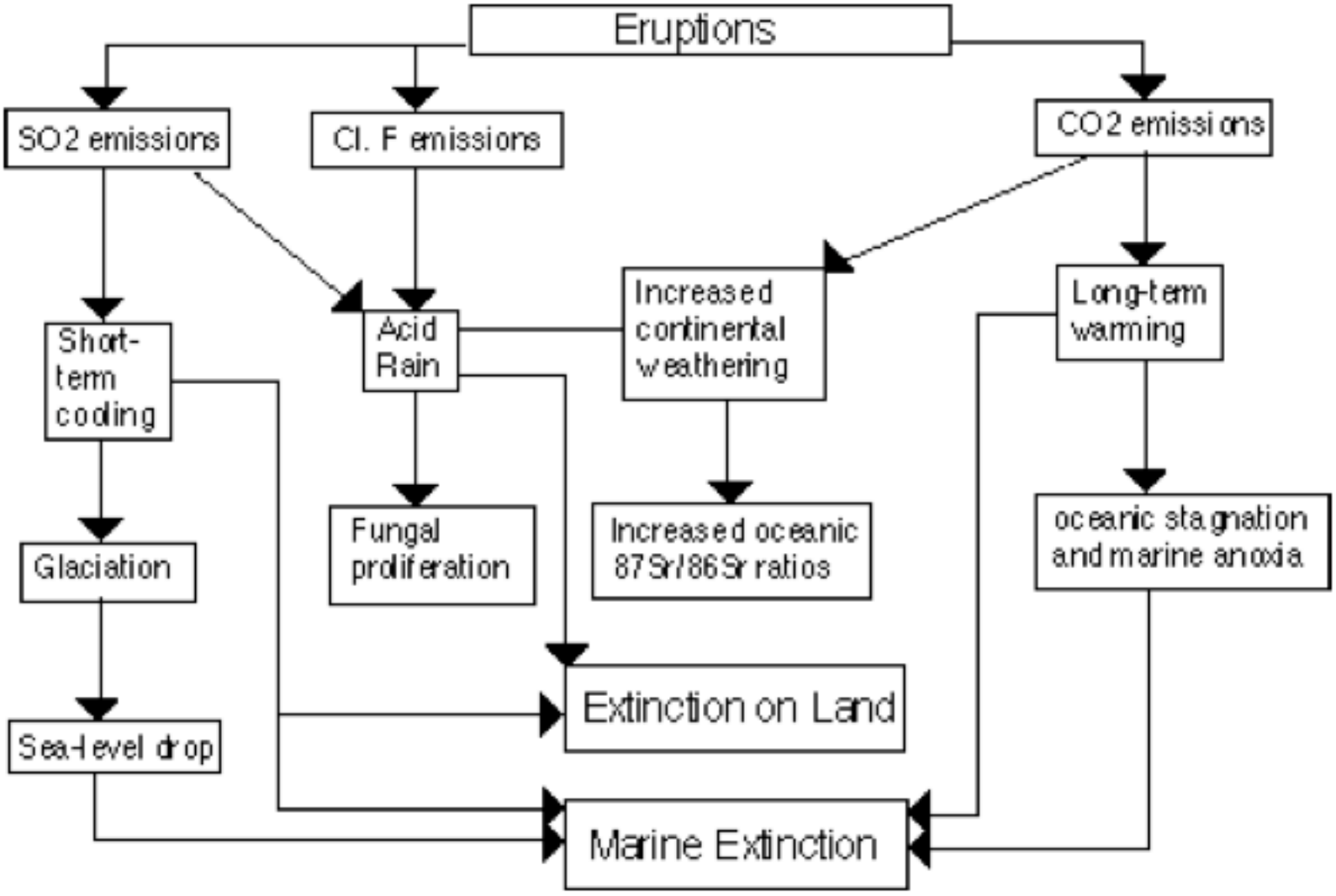
The real reason dinosaurs became extinct

Surge in Volcanic Eruptions?

- Deccan traps
- Huge uprise in eruptions in India
- Peak about 66 Myr ago; before K-T
- Gases might have played some role

http://www.whoi.edu/cms/images/oceanus/2006/3/map-enl_31798.jpg

Extinction by volcano ?



Iridium

- A key fact: at K-T geological boundaries, there is a layer that is enriched in iridium (rare heavy metal) by factors of hundreds
- Why???

http://ircamera.as.arizona.edu/NatSci102/NatSci102/images/ktboundary.jpg

Luis and Walter Alvarez

- Luis (father), physicist Nobel Prize, 1968
- Walter (son), geologist
- Combo, and two others, noted that iridium is common in asteroids
- Might there have been a giant impact?

Known Impacts: Meteor Crater

~50,000 years ago. 1 mile across; impactor 50m

http://www.lpi.usra.edu/science/kiefer/Education/SSRG2-Craters/meteor_crater.gif

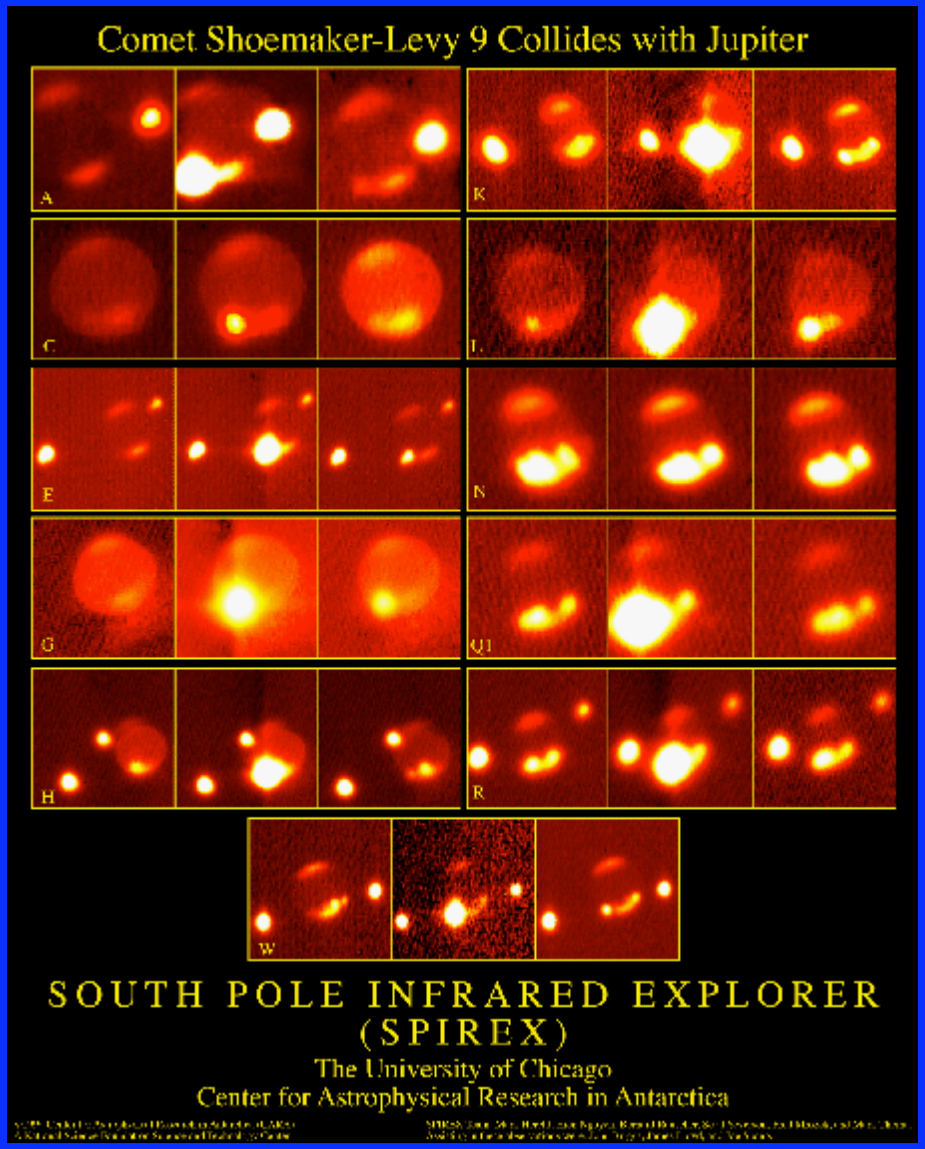
Known Impacts: Tunguska

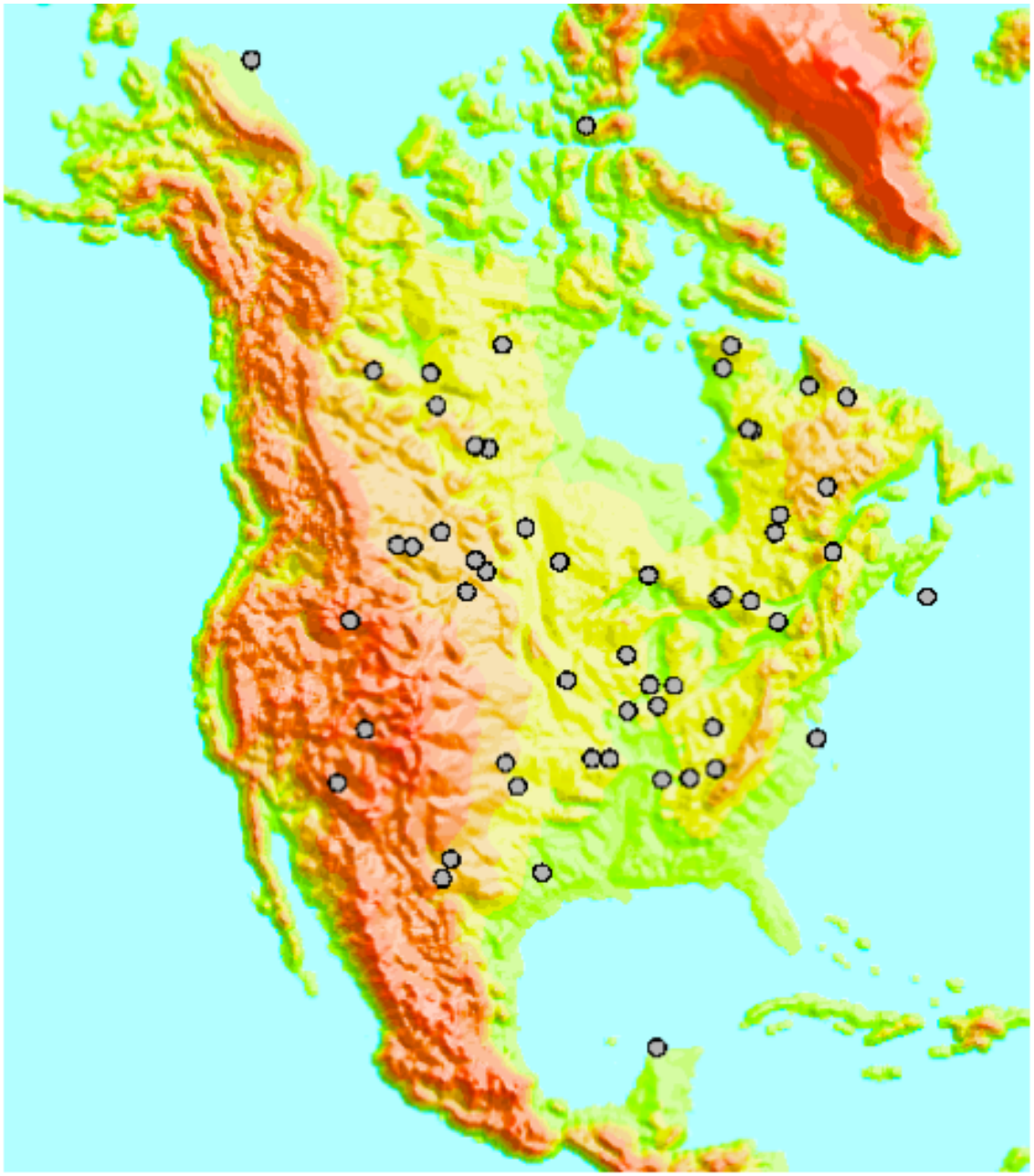
- Siberia, June 30, 1908
- Flattened 80 million trees over 830 sq miles
- Probably caused by small comet or asteroid
- No fatalities, but 4 hrs earlier would have hit St. Petersberg

http://johnstodderinexile.files.wordpress.com/2006/03/tunguska.jpg

Known Impacts: SL9

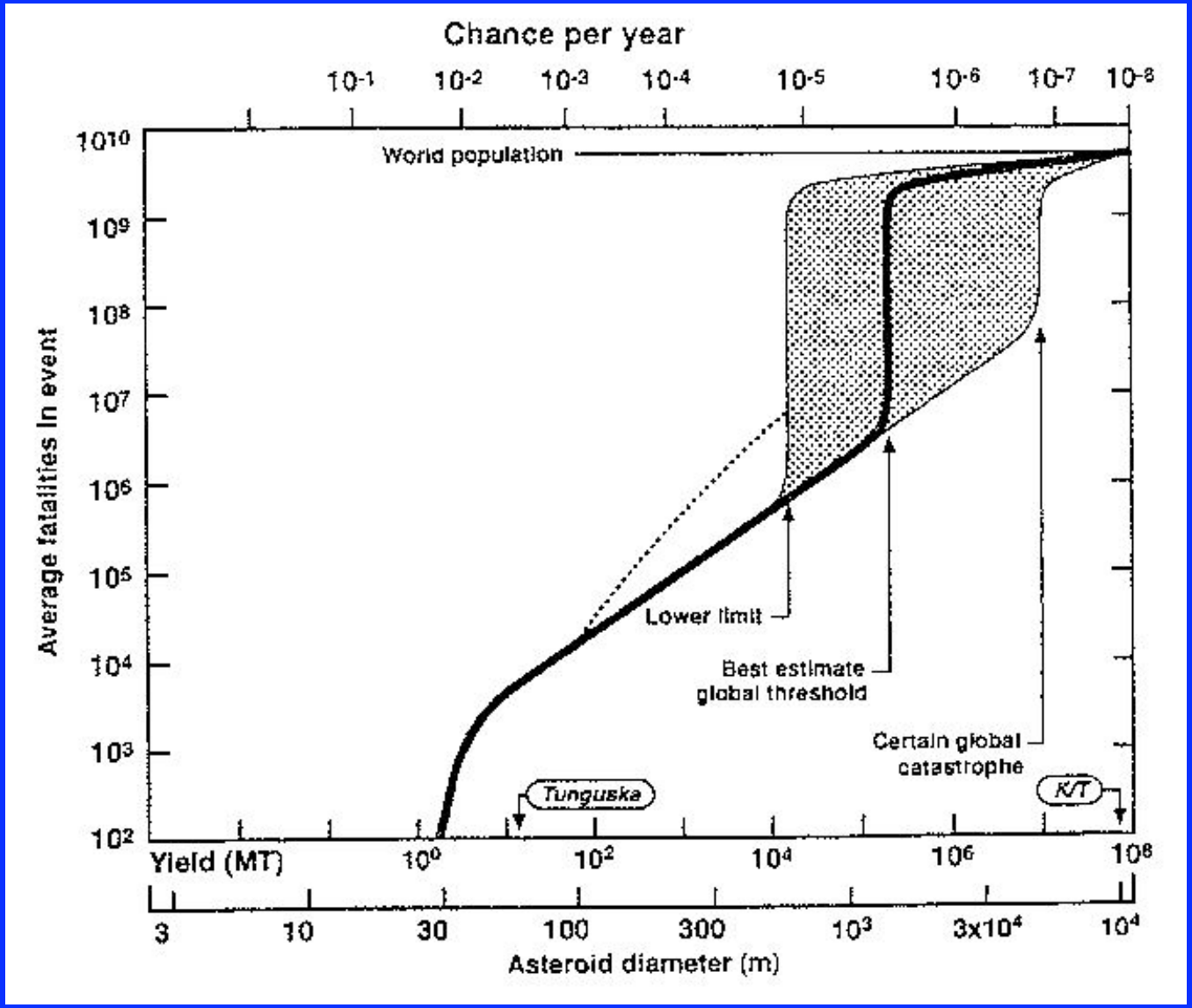
- Shoemaker-Levy 9
- Comet, broken into fragments by Jupiter's gravity
- >20 hit Jupiter in 1994
- Largest had energy of 6,000,000 megatons of TNT!





Impact craters in North America

Rates vs. Size



http://www.lsst.org/Science/images/bcfig4.jpg

How to Test Hypothesis?

- Impact matched rates and iridium
- But many geologists insisted that the volcanic eruptions that produced the Deccan traps were the extinction culprit
- How else could one test the impact hypothesis?

Candidate Crater

- Chicxulub crater
- Discovered in late 1970s; oil drilling
- Dated to 65 million years ago
- Clear impact; tektites etc.
- Convinced most people

http://www.sunstar-solutions.com/sunstar/geology/BigBend/Images/Chicxulub.jpg

Impact of an Impact

- K-T: 100 trillion tons of TNT equivalent
- Global dust, block photosynthesis for years "Nuclear winter"?
- Global firestorms; increase CO_2, cause greenhouse effect
- Possible acid rain

The Permian Extinction

- Most extensive ever
  240 million years ago
- 53% of marine *families* were killed off!
  18% for K-T
- Most famous victim: trilobites
- What caused this?
  Less certain, so let's explore

http://www.mineraltown.com/Reports/33/trilobites.jpg

Causes of Permian Extinction?

- Not clear
- Impact? Maybe, but tougher to nail down that long ago
- Volcanic eruptions?
- Climate change?
- Claimed recent evidence that the extinction was <160,000 years long, maybe <8,000 yrs

The Siberian Traps

("traps" = steps)

age ~250 million yrs

Precambrian Extinction

- 650 Myr ago
  Before hard parts!
- 70% of dominant flora, fauna extinct
- Possible causes? Ah, there lies a tale that speaks to the vitality of life and the special nature of water...

http://www.aboutextinction.com/images/Precambrian.jpg

Snowball Earth

- Evidence of equatorial glaciers, 600-700 Myr (if it happened; disputed)
- Why? Ice reflects light, so Earth grows cooler
- Maybe caused by arrangements of continents
- How would we escape?

http://nai.nasa.gov/newsletter/03182005/snowball.jpg

Escaping Snowball Earth

- If Snowball Earth happened, we obviously escaped. But how?
- Volcanic eruptions would eventually release enough CO_2 for greenhouse
- Radioactive decay energy trapped under ice would be released
- Ice floats, otherwise would settle and presumably wipe out ocean life

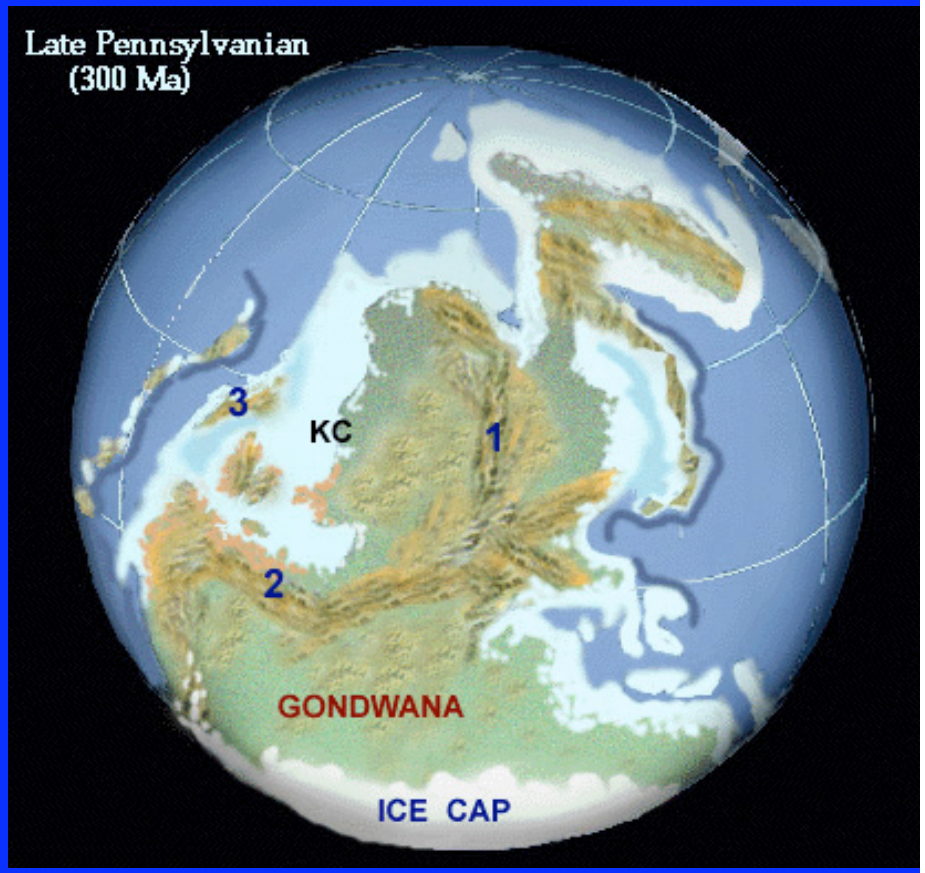
Ordovician Extinction

- 440-450 Myr ago
- Second most devastating in history
- More than 100 families of marine invertabrates went extinct
- What are possible causes?

http://www.science-art.com/gallery/20/20_632003193620.jpg

Glaciation of Gondwana

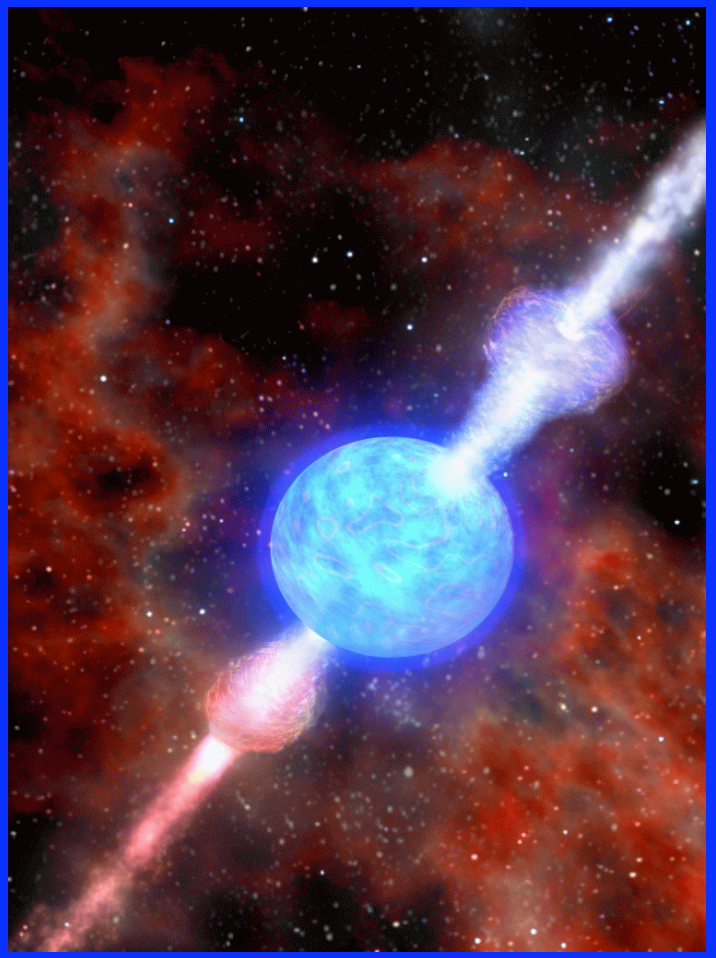
- Leading candidate: large scale glaciation
- Would cause global cooling and also lower sea levels (water tied up in glaciers)
- Reduce diversity of ecosystems



http://www.geospectra.net/lewis_cl/geology/pennglobe.jpg

Gamma-Ray Burst?

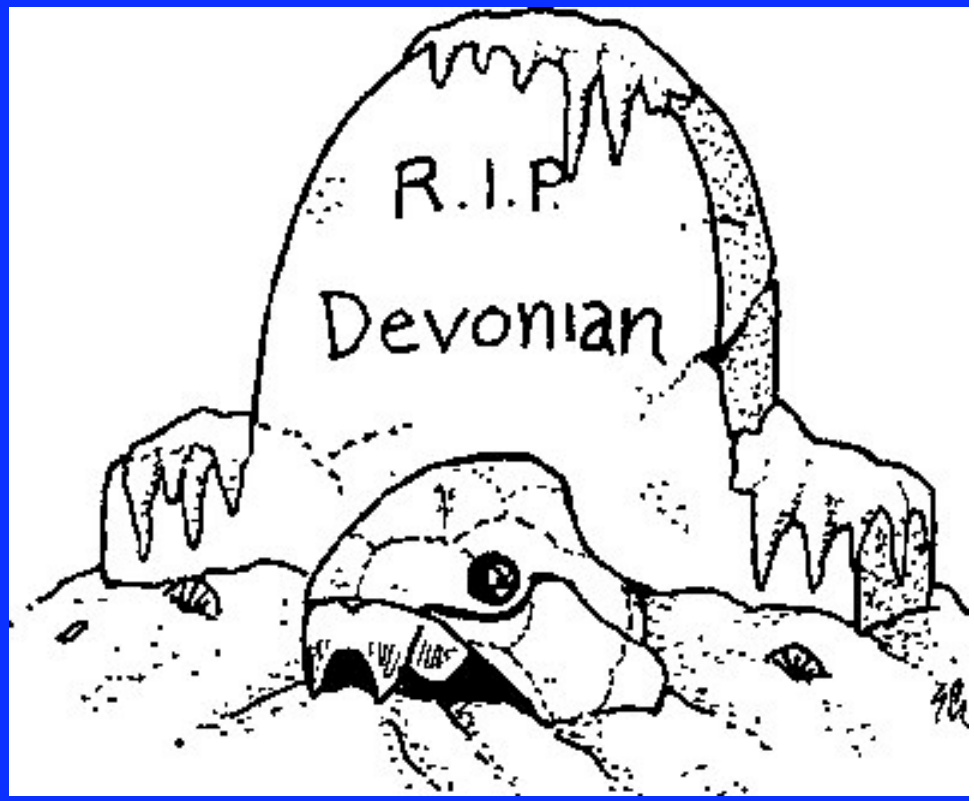
- Can occur when forming a black hole
- Jets close to light speed come out
- Extreme intensity in direction of jets
- If close enough, could remove UV protection
- Microbes, sea life might do better



http://astroguyz.com/wp-content/uploads/2009/03/grbtwinjet.gif

Devonian Extinction

- Devonian="age of fishes"; 375 Myr ago
- Not a lot known here
- Was series of smaller extinctions
- 75% of marine fish families died; freshwater hardly affected
- Sea hypoxia? Cooling? Meteorites?



http://www.uky.edu/KGS/education/images/dev_mass_extinction.jpg

Human-Induced Extinction

- Mainly habitat destruction, pollution
- At current rate, estimate half of all species extinct within next 100 years; rate is increasing
- Would be faster than any on record

http://www.mongabay.com/images/peru/aerial-rainforest/Flight_1022_1554.JPG

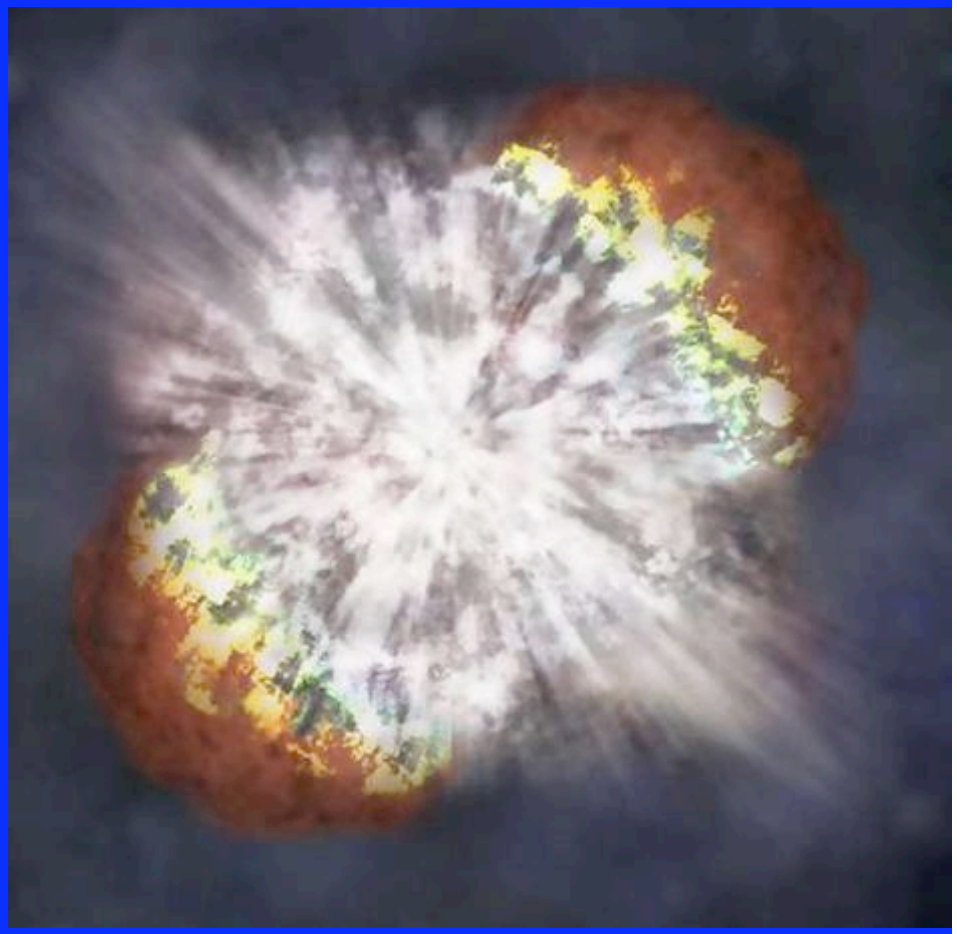
Could All Life be Extinguished?

- Super-giant impact?
- 100 km would have 1000x K-T energy
- But bacteria in rock, deep ocean would probably survive
- Might kill off humans

http://www.resonancepub.com/images/asteroid_impact.gif

Death by Supernova?

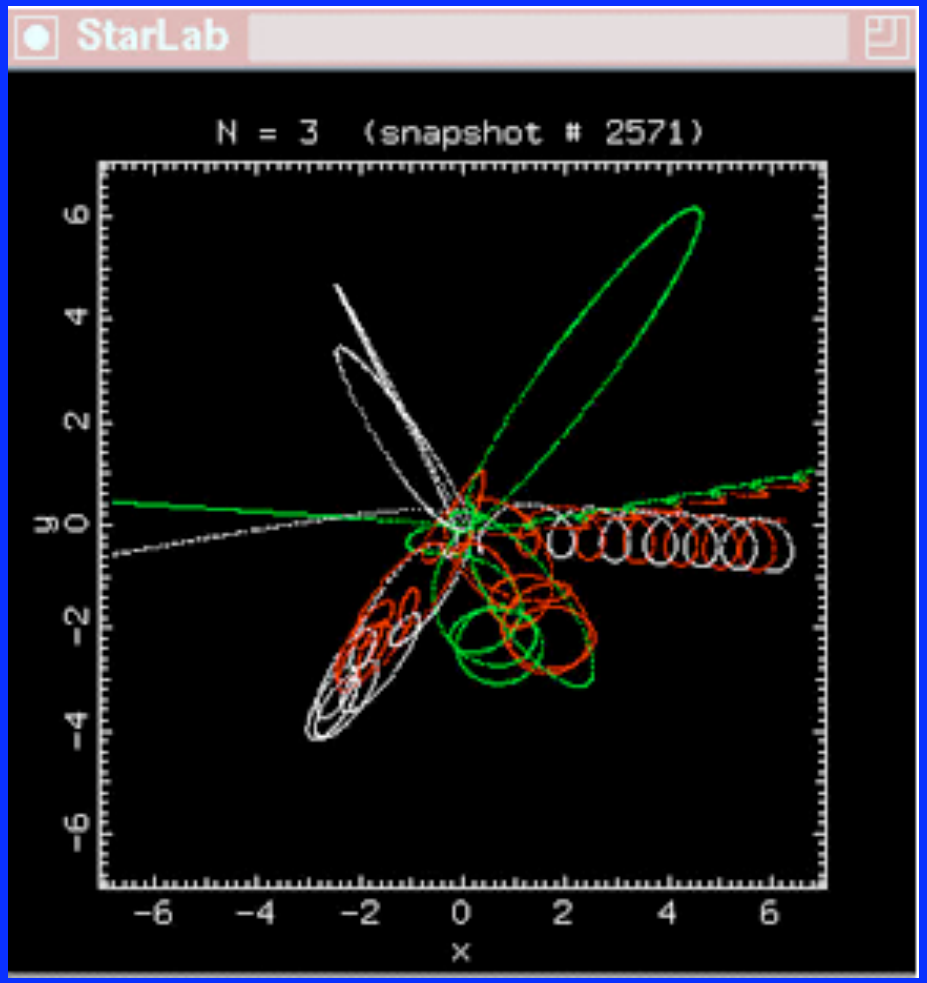
- Exploding star, 10^{10} times brighter than Sun for months
- At 1 parsec, would double heat from Sun
- Some bacteria would probably survive
- Don't worry, nearest prospect hundreds of parsecs away



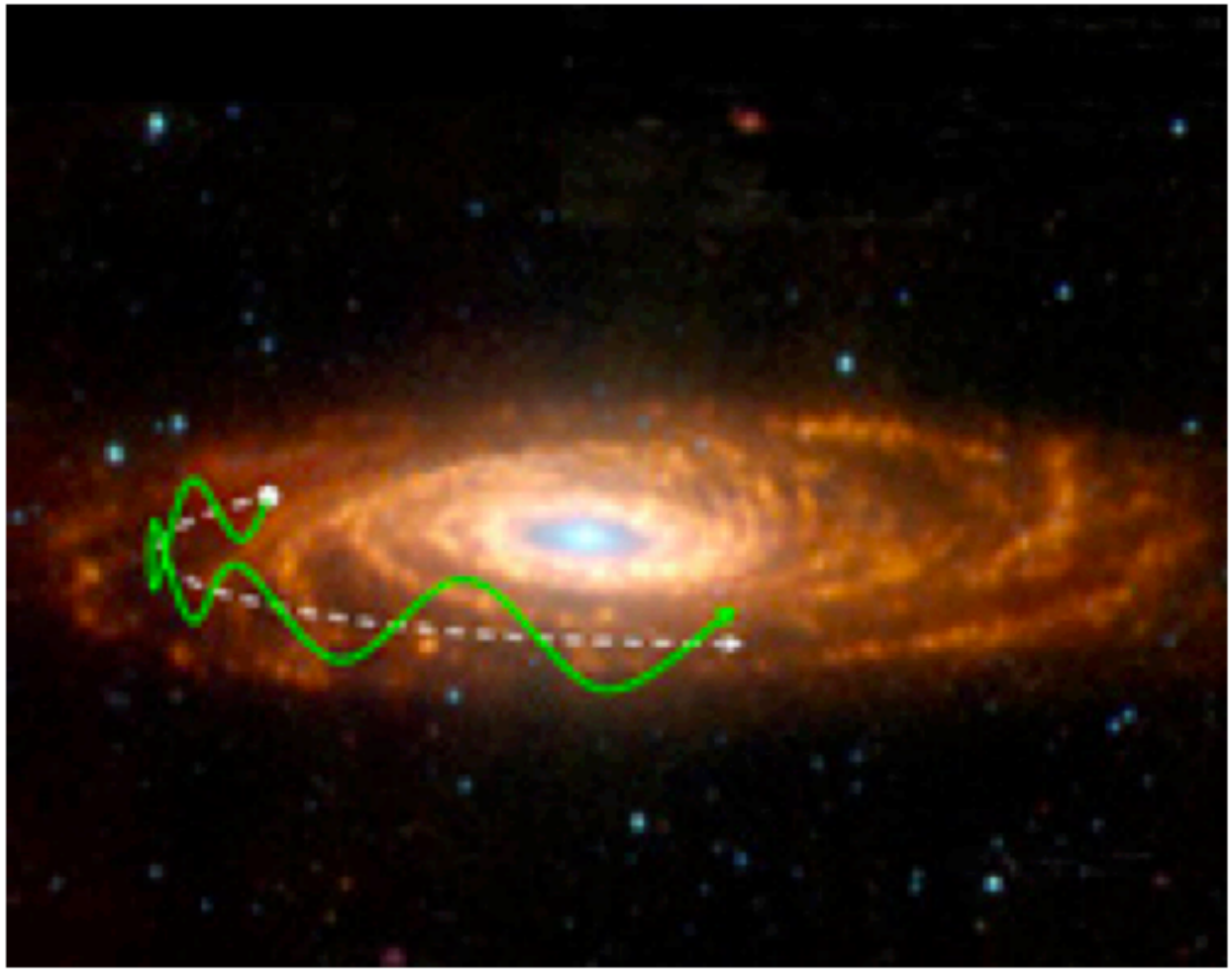
http://www.smh.com.au/ffximage/2007/05/08/supernova_wideweb__470x458,0.jpg

Stellar Kidnapping?

- If star passed close, could kick Earth into interstellar space
  Or send asteroids careening around
- Expected time: trillions of years
  Don't worry!
- Would be problem in dense stellar environment like globular cluster



Matt Benacquista



The Solar System passes through the plane of the Galaxy every 30 million years (approximately!)

Could this disturb the Oort comet cloud ?

Benefits of Mass Extinction

- Opens up many evolutionary niches
- Consider:
  Precambrian --- animal explosion
  Permian --- dinosaurs and mammals
  K-T --- big mammals and eventually us!
- "A little rebellion, now and then, is a good thing" --- Thomas Jefferson

Summary

- Many mass extinctions; five big ones in last 540 million years
- Always animals/plants survived, undoubtedly bacteria/archea too
- Some would be serious enough to kill us off
- But benefit is allowing new species to emerge