Some Suggested Project Topics

Following are some suggested topics for projects. They are listed under four main areas of the curriculum (space and time, cosmology, origin of the elements, origin of life). Pick one and adapt it, or come up with your own question. **Submit a written proposal to your TA before October 4th and** get it approved. **If your presentation is in the first week of presentations you should try to get your proposal to your TA EARLY!** You may need to talk with your TA about your intended project.

Once you have chosen a topic and researched it, develop a **15 minute** presentation to be given in your tutorial group. Prepare a one-page "handout" for your tutorial group.

Talk about any other ideas with us, anytime.

History of the Universe: Cosmology and Astronomy

1. How does cosmology collect and use "evidence" compared with the way that laboratory physics or biology collects evidence?
2. How would you characterize the difference in style or nature of questions between cosmology today and the cosmology in the time of ancient Greece? Use specific scientists/scholars as example cases if you want.
3. Whatever happened to the Steady State cosmological model? What was it, and why did it lose out to the Big Bang model of cosmology? How does it illustrate the scientific process of testing out ideas?
4. What is the Anthropic Principle? Does it mean anything for limiting the range of possibilities for the type of universe we could live in?
5. What did Plato believe about how the universe was organized? What was important about his work?
6. It's been said that we are now living in the "second golden age" of astronomy, and that the "first golden age" was the time of Galileo. What did Galileo do and how was he responsible for starting off modern astronomy?
7. Globular star clusters are relevant to cosmology. How and why?
8. Galaxies come in clusters, and clusters group into superclusters ..... does this hierarchy of bigger and bigger groups stop eventually? What is the current evidence and is it consistent with the Cosmological Principle?
9. We know what the night sky looks like now from Earth. Think of an imaginary planet around a star at a time just 1 billion years after the Big Bang. What would the night sky have looked like then? What would have been the differences?
10. There must have been a very first generation of stars in the universe. What were those stars like, according to current ideas?

11. Would the Earth be a safer place to live if Jupiter were not present in the Solar System? What if Jupiter, or a large planet like it, had never been there – discuss the implications for evolution of life on Earth.
12. In view of the recent discoveries of real planets around other stars, how well justified are we in thinking that Earth-type planets are common (or rare)?
13. In a short story "Nightfall" by Isaac Asimov (perhaps the most famous classic science fiction story ever written) the setting was a planet around a star inside a globular cluster. Describe accurately what the night sky would look like from such a location.
14. Discuss the role that the Moon may have played in the origin of life on Earth. A good source for discussion is the book "Rare Earths" by Ward & Brownlee.
15. Devise some better classroom-type demonstrations for Olbers' Paradox and Hubble's Law. Originality will count!
16. How might our conclusions about cosmology be different if the cosmic background radiation were not there at all? Could we still put such strong faith in the Big Bang model?
17. What are the chances that a nearby supernova would destroy human civilization in the foreseeable future?
18. Why would the collision of a large comet with the Earth be catastrophic – what does such an impact actually do to/for the biosphere?
19. Did the ancient Greek astronomers (Ptolemy, Aristotle, and others) actually think of the universe as being finite in size? What was their estimate and how did they get it?
20. What kinds of resources would be needed to travel to Venus? How long would it take and what would be the problems with successfully making the trip

Nature of Space and Time

21. Alan P. Lightman wrote a small book "Einstein's Dreams", a fictional account of the dreams of a patent clerk. These dreams explored the meaning of time and what life would be like if time were different. Read the book. Choose one or more of the dreams. Elaborate. How would life be different in such a condition?
22. Galileo reportedly did a famous experiment at the Leaning Tower of Pisa. Apparently he dropped objects and observed that they all fell at the same rate. How has our understanding of this experiment changed from Newton to the General Theory?
23. Shortly after the publication of Einstein's General Theory of Relativity observations were made of a solar eclipse. Read and report about the expeditions to make these measurements. How and why do you suppose this captured the imagination of the general public?
24. "There once was a young man named Bright,
    Who travelled much faster than light.

He left one day,
In a relative way,
And returned the previous night."

What are the implications of such travel in time?

25. Some objects in space appear to be superluminary, i.e. they appear to be traveling faster than the speed of light. Can you explain how this could be so?
26. The nearest star to our sun is about 4 light-years away. Will it be possible for humankind to visit this star?
27. Some modern experiments have attempted to determine whether or not gravity continues with a r^{-2} dependence at short distances. What is the reason for such experiments? Have they noticed an effect? Speculate.
28. Einstein is reported to have said that he believed that "God doesn't play dice". What do you think that he meant by this?
29. A motorist explained to a judge that he had not stopped at a red light because relativistic effects had changed the colour of the light. How are colours changed in special and general relativity? Should the motorist be fined?
30. A ball rolls inside a bowl. If it doesn't have enough energy, it can't get out. However an electron moving inside a much smaller "bowl" sometimes may "tunnel" through the bowl and get out. How can this be so?
31. Is the universe "closed"? What are the future consequences of closed and open universes?

Formation of the Elements

32. In the early universe, there was a hot mixture of protons, electrons, neutrons and light. The protons later on become the nuclei of hydrogen atoms, and some of the neutrons combine with some of the protons to make helium nuclei. But: What happened to all the rest of the neutrons?? What became of them?

33. Discuss neutrinos and their properties. How are neutrinos made in the sun? How do we study them? What is the "Solar neutrino problem" and what appears to be its solution?

34. Discuss gamma-ray bursts. How are they found? What are some current ideas on what they are?

35. What are neutron stars and pulsars? How were they discovered? Tell the story.

36. Supernovae: the story of SN 1987A

37. Do intermediate mass black holes exist? Discuss the evidence and how the measurements are made.

38. What do we know about “cosmic rays?” What are some remaining open questions? Discuss how they might be relevant to our understanding of the elements in the universe.

39. Another type of stellar explosion is the “Nova” (as opposed to the Supernova). Discuss what we know about Nova explosions from observations and models.

40. Discuss how measuring the element abundances in very old stars and comparing them to the present element abundances in our solar system has contributed to our understanding of how elements heavier than iron are formed.

41. How do terrestrial experiments involving the use of particle accelerators help us understand the role of atomic nuclei in stars and in the cosmos? As examples, discuss the TRIUMF facility in Vancouver where rare atomic nuclei are produced and accelerated for use in experiments, and/or the Relativistic Heavy Ion Collider (RHIC) in New York where ions of gold are collided together at extremely high speeds. You can compare and contrast the two laboratories and their science goals, or focus on one facility only.

Life in the Universe

42. Explore the role of meteorites and comets in bringing organic molecules to Earth.

43. Life on Mars? What experiments have been sent on spacecraft (or are planned for future missions) that might determine whether there is/was life on Mars? How much have these experiments told us?

44. Artificial Life. What is the objective of this field of computer science? What has been achieved with programs such as Tierra?