Some preliminary questions.

1. Before asking why we sleep, let's think about a different issue: Why do we have hair on our heads?
   - What does this question mean?
   - What kind of evidence would you look for to get an answer?
   - What kinds of answers would be acceptable? Would some be unacceptable?

A sampling of theories.

Any theory of sleep must account for several universal characteristics of sleep, including that sleep is:

- found in all mammals and birds, plus probably in reptiles and some amphibians
- cannot be replaced by waking rest
- is homeostatic and circadian
- is characterized by physiological and brain states that are not otherwise obtainable easily
- includes unconsciousness/reduced sensitivity to external stimuli
- has two distinct components...REM & NREM (active & quiet), each with its own distinct physiological and brain states

Theory 1: Rest and Restoration

- Supporting evidence: (Gwen, Grace, DJ)
  - deprivation produces rebound, dysfunction & death
  - rebound is proportional to sleep lost
  - human growth hormone, insulin, cortisol, hunger and sympathetic nervous system regulation are all disrupted in deprivation
- adenosine
- Contradictory evidence: (Jackie, Alejandra, Taryn)
  - cellular repair & regeneration involves protein synthesis...which decreases during sleep
  - glycogen (energy) regeneration occurs only early during sleep...so why do we keep sleeping?
  - even in Rechstaffen’s 30-day deprived animals that died, post-mortem exams revealed no obvious harm to major organ systems.
  - why would unconsciousness be an integral part of sleep...doesn’t seem necessary for rest and restoration.
  - why the 2 stages of sleep, one of which involves increased arousal of body and brain?

Theory 2: Energy Conservation

- Supporting Evidence: (Erica, Kelsey, Susan)
  - Some of the primary characteristics of sleep are rest, low energy consumption and lower body temp.
  - Why else except to conserve energy?
  - Similarly, true NREM sleep seems to have developed independently in many species concurrent w/ the development of endothermy (constant body temp)...these are precisely the species w/ the most to
gain from energy conservation.
- Correlation of +.63 between sleep length and metabolic rate...in other words, those species who save the most energy by sleeping are the ones who sleep longest.
- Also, the correlation of -.53 between body weight and sleep length...the smallest animals tend to sleep the longest. The animals w/ the lowest mass lose heat the quickest and so have the most trouble maintaining body temp...they may have the most to gain from the lower body temp that comes with sleep.
- **Contradictory Evidence:** (John, Aschley, Caitlin)
  - All of the “evidence” above is nothing more than post hoc rationalization (i.e., Monday morning quarterbacking)
  - Regarding the point about body size and sleep...movement creates heat and helps to keep body temp up...if a small animal has an ample food supply, it would benefit (in body temp terms) from keeping active, not from sleeping.

**Theory 3: Behavioral Adaptation**

- **Supporting Evidence:** (Dylan, Tracey, Lauren)
  - This theory just seems to make sense on the face of it...the night was a dangerous place for our ancestors and less food was readily available then, so individuals that moved around less at night were more likely to survive...this led to sleep.
  - Species that are safe when they sleep (bats, cats, etc) tend to sleep longer than species that are in jeopardy when they sleep (large prey animals)
- **Contradictory Evidence:** (Blair, Tony, Amy)
  - The most striking single change that occurs with the onset of sleep is a reduction in sensitivity to sensory input, especially during REM...how on earth does that help an animal stay safe from predators?
  - Species in which sleep is counter-adaptive (dolphins and whales) still show sleep.
  - If this theory were correct, why not just have quiet rest instead of sleep...much more adaptive.

**Theory 4: The Brain Needs the Downtime That Comes With Sleep**

- **Supporting Evidence:** (Egypt, Amanda, Sarah)
  - James Horne: Many of the effects of sleep deprivation are brain-based. For example, consider some of the effects shown by Randy Gardner: irritability, difficulty recognizing objects only by touch, memory lapses, difficulty concentrating, hallucinations, difficulty naming common objects, fragmented thinking and paranoia.
  - J. Allan Hobson: neurons that are highly active when awake may deplete their supplies of neurotransmitters and need time to recover, while those not often used when awake need the chance to be stimulated on a regular basis.
  - Kavanau: memory circuits and synapses need to be periodically activated or they weaken...that may be why the sleep reduction in old age is correlated w/ memory loss.
  - **PBS Nova:** sleep is the time when the brain processes/edits information from the previous day.
- **Contradictory Evidence:** (Courtney, Sa)
  - Many of the brain-based problems may really reflect circadian rhythm disruptions, not sleep deprivation.
  - If neurons need to rest and replenish their neurotransmitters, why REM?
  - If sleep is needed to rest the brain and restore cognitive function, why is sleep seen so widely in so many animal species, some with much simpler brains

**A closer look: The Synaptic Homeostasis Hypothesis**

- First, some background:
  - Neural networks, consolidation and pruning
  - Gene expression/transcription = gene activity = protein production = synapse strengthening and weakening, memory, etc.
- The article: **The Scientist, April 2009**
- A page by page reading guide:
  - p 34
    - What are the basic procedures and finding of the Cirelli & Tononi experiment that's being replicated?
    - What are the two competing explanations for these findings?
    - What role are delta waves hypothesized to play in the Cirelli & Tononi view? What's the evidence?
- p 37
  - What was the Pavlides & Wilson (1989) study all about? Which of the 2 explanations from p 34 does this study support?
  - The two paragraphs in the middle column, starting with "At the time, Tononi..." are critical. What do they mean?
- p 38
  - Be ready to explain the Synaptic Homeostasis model on this page
- p 39
  - What is the Eric Landsness experiment about? Do his findings support or weaken the homeostasis model?
- p 40
  - What does the Cirelli and Tononi theory say about REM? How about the memory replay and consolidation theory?