Humans 2.0

Improving the Human Condition

Anonymous students PF, CM, CN, and DZ

What If We Didn't Need Sleep?

It would make the "choose two: {sleep, grades, friends}" dilemma so much simpler…

Importance

- Sleep affects everyone!
- Serious problems/effects of sleep deprivation
  - Decreased mental function (memory, recognition, etc.)
  - Cardiovascular problems, weight gain

Impact

- Start with specific applications: large “delta” for small population
  - Military, College students, etc.
- Expand to broad applications: smaller “delta” for large population
  - General productivity booster?
- Short- and long-term health risks?

Photo of yawning man
removed due to copyright restrictions.

Knowns/Unknowns

- Much is still unknown about sleep
  - Why do we sleep at all?
  - What are the results of sleeping?
- What we know about sleep
  - 4 Stages: N1, N2, N3, REM
  - Occurs in cycles lasting 90-110 mins.
  - N3, REM are “deep sleep” cycles
  - REM only accounts for ~30% of sleep
  - Possible to “isolate” REM sleep?

Image of cartoon cat "Garfield" in pajamas with cup of coffee removed due to copyright restrictions.

Competition

- Many research institutions are investigating the causes/effects of sleep
- Drug stimulants
  - Caffeine!
  - Modafinil

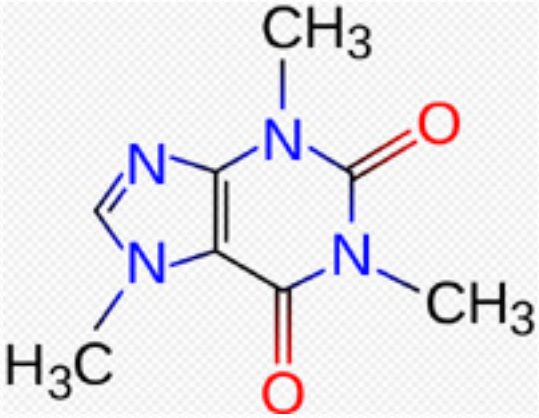

Image: Wikpedia (public domain)

Courtesy of Rynosoft on Flickr.

Our Idea

- "Curing" sleep might be too ambitious, given how little is known about the causes of sleep
- Increase the level of tolerance for caffeine by manipulating the adenosine receptors

Photo of sleepy person with 2 coffee cups removed due to copyright restrictions.

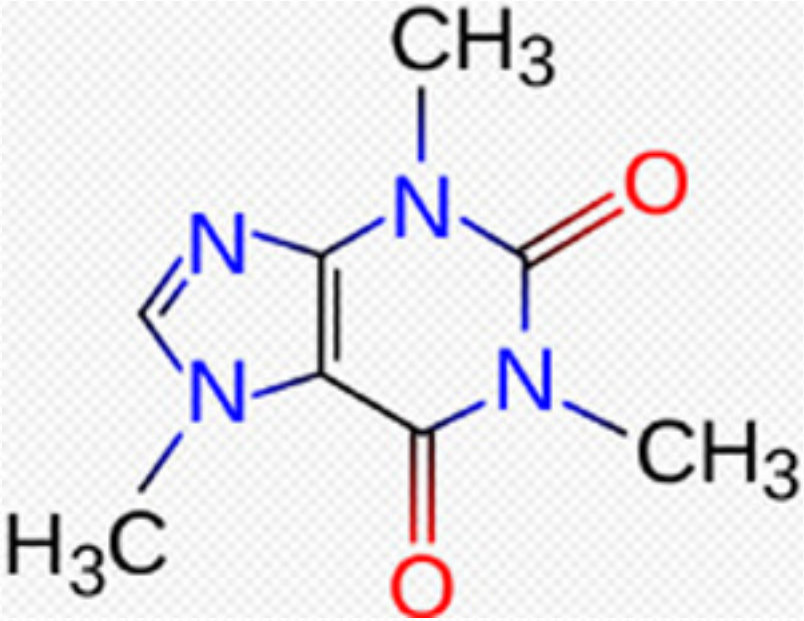

Image: Wikpedia (public domain)

- Although sleep is not fully understood, the manipulation of neural receptors could play an important role in increasing tolerance to sleep deprivation
- Another important method for improving the functioning of the brain, and particularly for healing the damaged brain, is through the regeneration of neurons

Neuron Regeneration!

Brain damage? No problem! ☺

Importance

- There is no way to repair damaged neurons
- Serious problems!
  - Loss of motor functions
  - Brain disorders
  - Dead neurons

Impact

- Affects only a limited segment of the population (injury, Alzheimer's, etc.) – but impact would be tremendous.
- Would allow those who suffer from brain damage to have returned physical and mental functioning

Drawing of neurons removed
due to copyright restrictions.

Competing Technologies

- Use of stem cells to replace damaged neurons
- Stimulation of nerve cells to help regrow neural connections in the brain
- Turning off or blocking pathways that inhibit regrowth of neurons
  - Three inhibitors of axon regrowth known to date are Nogo, myelin-associated glycoprotein (MAG) and myelin-oligodendrocyte glycoprotein (OMgp)

Knowns

- Basic structure of neurons
- Neural pathways and the use of neurotransmitters to communicate within the brain
- Neurons can be regenerated with the use of stem cells

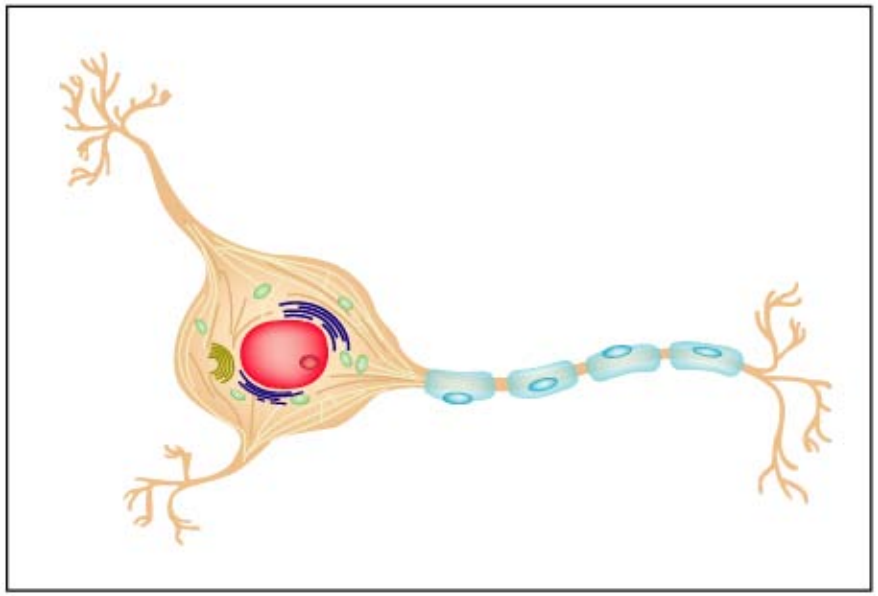

Figure by MIT OpenCourseWare.

Unknowns

- Efficient techniques for replacing damaged neurons
- Nature of genes associated with the regeneration of neurons

Image of neurons
removed due to copyright restrictions.

- Neurons within the adult brain that regrow axial projections have been found, but the genes that encode for this growth and the proteins that they translate are not well known

- Inserting regenerated neurons into the brain or stimulating the regeneration of neurons within the brain could allow for the recovery of mental and physical functioning

Image of neurons
removed due to copyright restrictions.

- Neuron regeneration could help to cure patients who suffer from neurodegenerative diseases, such as Alzheimer's

Alzheimer's: A Bioengineering Approach

Importance

- Highly degenerative disease that is ultimately fatal
- Lowers the quality of life and decreases the capacity to function of society of those who suffer from it
- An estimated 26.6 million people 65 years and older had Alzheimer's worldwide in 2006
- Thus Alzheimer's has terrible and irreversible degenerative effects on a large number of people

Impact

- Memory makes you who you are!
- Will help people with Alzheimer's and other forms of dementia retain their lifelong experiences
- Preserves family unity
- Reduces Human Suffering

Image removed due to copyright restrictions.
Diagram comparing hemispheres of healthy and Alzheimer's brains. See: http://www.alz.org/brain/09.asp

How to stop the loss?

- Rearrange the fibers to their original position
- KILL the plaques
- We are proposing to monitor them using “bio-markers”

Issues for Treatment

- Blood-Brain Barrier
- Limited Imaging of the Brain

Image removed due to copyright restrictions.
Neurons of healthy and Alzheimer's brains.
See: http://www.alz.org/brain/10.asp

Knowns

- Senile plaques and neurofibrillary tangles are directly associated with Alzheimer's
- Possible Genetic Component: Mutations on Chromosomes 9 and 19
- The cells ultimately die
- Causes the brain to shrink
- Protein pieces clump together in the brain
- Chemically "sticky" (they bond easily)
- The clumps block signals and ultimately kill the cells!!

Unknowns

- What causes plaques to form
- What types of neurons are affected
  - Why are certain areas of the brain affected
- Structure of the protein plaques
- Time that it takes the clumps to be “big” enough to block the neuro-signals
- “Twisted” Proteins: What causes them to entangle?

Competing Technologies

- Many pharmaceutical treatments focus on neurotransmitters NOT on plaques and tangles
- Clinical Trials
- The U.S. Food and Drug Administration has approved four drugs to treat AD. For people with mild or moderate AD, donepezil (Aricept®), rivastigmine (Exelon®), or galantamine (Razadyne®).
- Namenda regulates glutamate which plays a key role in processing information.
- Treatments Researched: Breaking down beta-amyloid plaques, anti-inflammatory drugs

Summary

- Manipulating receptors on neurons can play a major role in the transfer of information through neural pathways
  - Changing adenosine receptors can help increase tolerance to caffeine
    - Caffeine supplements could be more continuously effective in decreasing the need for sleep
  - Changing neural receptors can also allow for specific drug treatments and chemicals to be transferred to neurons for medicinal purposes
- Regeneration of neurons is a major concern since most neurons are in a state of non-replication
- The regeneration of neurons could allow for the treatment of patients with Alzheimer's and other forms of dementia
- The removal of plaques and the detangling of neurofibers could improve neural functioning and ultimately help to prevent the progression of Alzheimer's

Resources

- http://www.pnas.org/content/100/13/7430.full
- http://www.alseres.com/science-technology/nerve-repair.asp
- http://www.narcis.info/research/RecordID/OND1325851/Language/en/;jsessionid=1ohc281m2bl
- http://alzheimersdiseaseaid.com/origins-unknown--the-battle-with-alzheimer-s-continues.php
- http://www.nia.nih.gov/Alzheimers/AlzheimersInformation/Treatment/ http://alzheimers.about.com/od/treatmentofalzheimers/a/treatments.htm
- http://web.mit.edu/newsoffice/2008/alzheimers-protein-0821.html http://www.nanowerk.com/spotlight/spotid=5262.php

20.020 Introduction to Biological Engineering Design

Spring 2009