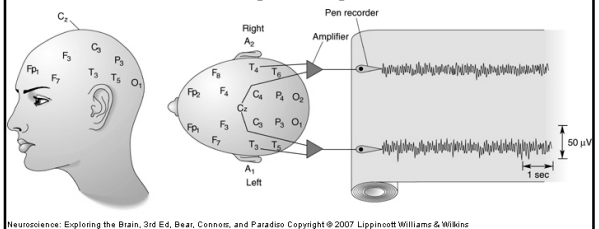
The Electroencephalogram (EEG)



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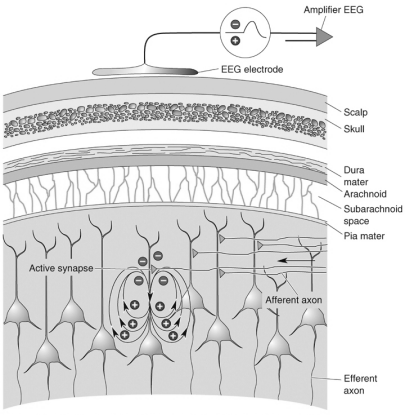
Allows us to measure or glimpse at the generalized activity of the cerebral cortex



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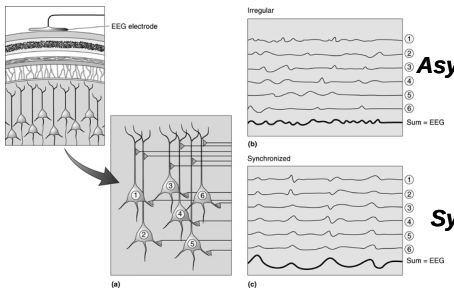
An *EEG* measures the currents that flow during synaptic excitation of the dendrites of many pyramidal neurons in the cerebral cortex, which lie right under the skull and makes up 80% of the brain's mass.

When each cell receives the same amount of excitation, but spread out in time, the summed signals are meager and irregular.



Asynchronous

Synchronous

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When a group of cells is excited simultaneously, the tiny signals sum to generate one large surface signal.

Generation of a Synchronous Rhythm

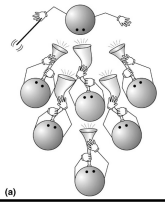
They may take their cue from a central ***clock or pacemaker***.

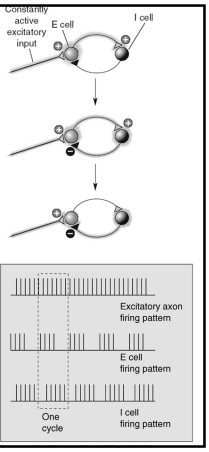
This mechanism is analogous to a leader and a band, with each musician playing in strict time to the baton's changing beat.

Best Candidate for this:

The **Thalamus** can act as a powerful pacemaker for the cortex.

- generating rhythmic activity
- specialized voltage-gated ion channels allow for generation of rhythmic and self-sustained activity (even in the lack of external stimuli to the cells)

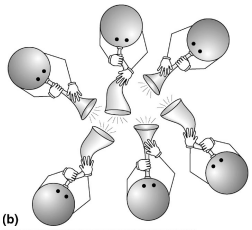


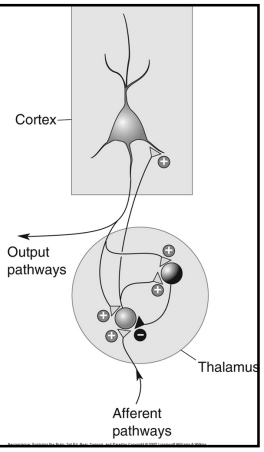


Generation of a Synchronous Rhythm

They may share or distribute the timing function among themselves by mutually exciting or inhibiting one another.

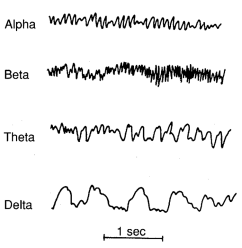
This mechanism is more subtle, because the timing arises from the collective behavior of the cortical neurons themselves. (Jam Session or "The Wave" at a ball game)





EEG Rhythms

The rhythms are categorized by their frequency range, and each range is named after a Greek letter.



Alpha rhythms are about 8-13Hz and are associated with quiet, waking states.

Beta rhythms are fastest, anything greater than about 14 Hz, and signal an activated cortex.

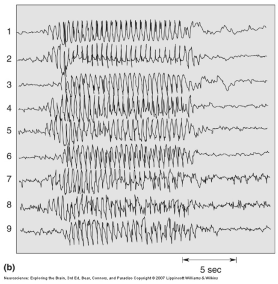
Theta rhythms are about 4-7 Hz and occur during some sleep states.

Delta rhythms are quiet slow, less than 4 Hz, often large in amplitude, and are a hallmark of deep sleep.

High-frequency / low-amplitude rhythms are associated with alertness and waking, or the dreaming stages of sleep.

Low-frequency / high-amplitude rhythms are associated with nondreaming sleep states, or the pathological state of coma.

What the heck is SLEEP?



Sleep is a readily reversible state of reduced responsiveness to, and interaction with, the environment.

Table 19.1 Characteristics of the Three Functional States of the Brain

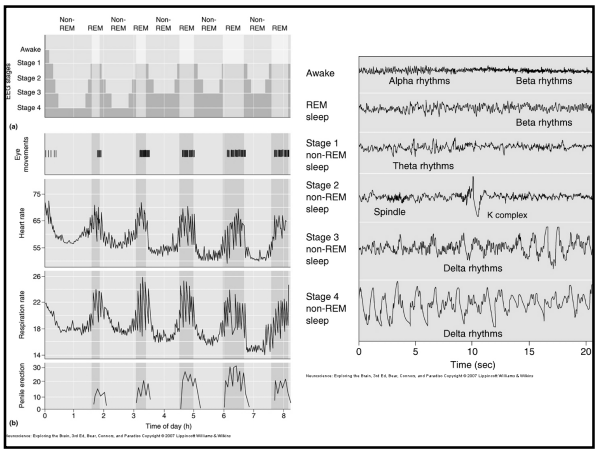
BEHAVIOR	AWAKE	NON-REM SLEEP	REM SLEEP
EEG	Low voltage, fast	High voltage, slow	Low voltage, fast
Sensation	Vivid, externally generated	Dull or absent	Vivid, internally generated
Thought	Logical, progressive	Logical, repetitive	Vivid, illogical, bizarre
Movement	Continuous, voluntary	Occasional, involuntary	Muscle paralysis; movement commanded by the brain but not carried out
Rapid eye movement	Often	Rare	Often

Non-REM:

- period of rest? Body is capable of movement, but rarely does the brain command it.
- parasympathetic activity is dominate.
- CNS energy and firing rates are low.
- slow, large-amplitude EEG rhythms (high synchrony, delta waves)
- most sensory input is not getting to the cortex.
- dreams can occur

REM:

- Very active forebrain! EEG similar to awake state. (Paradoxical Sleep)
- Dreaming sleep.
- Atonia except for respiration, heart rate, and eye movements.
- Dominated by sympathetic mechanisms

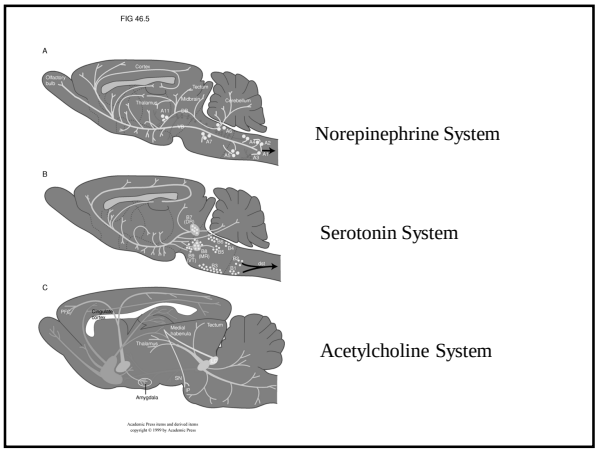


Neural Mechanisms of Sleep

Sleep is an active process that requires several region of the CNS.

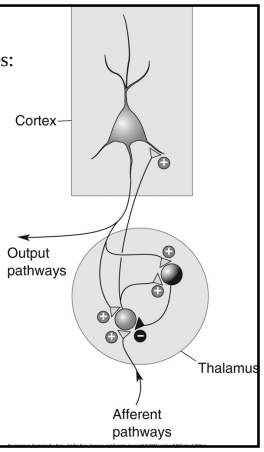
The controlling components of the CNS responsible for sleep utilize:

- Brainstem modulatory (Locus Coeruleus, Raphe Nuclei, and the whole Reticular Activating System) neurons using –
  - NE and Serotonin secreting neurons during waking and to enhance waking states.
  - Ach secreting neurons to initiate REM sleep.
- These brainstem modulatory centers control the rhythmic activity of the thalamus, slowing or inhibiting sensory info getting to the cortex.
- These brainstem modulatory centers also control descending information associated with motor control.



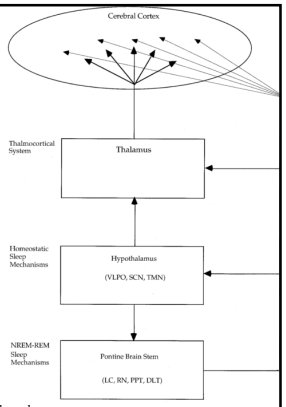
Falling asleep and the non-REM stages:

- Decrease in firing rate of brainstem modulatory neurons
- This decrease allows the specialized/rhythmic neurons of the Thalamus to work on there own (generating their own rhythmic activity)
- Activity/excitation going to the cortex becomes more synchronous forming larger wave forms (Delta waves).



REM Sleep Mechanisms:

- The cortex is necessary for the elaborate material of dreams, but the initiation of REM sleep is not dependent on the cortex.
- A marked decrease in activity of the Locus Coeruleus and Raphe Nuclei and a large increase in activity from Pons-based Acetylcholine neurons (inducing REM)
- This increased Acetylcholine activity from Pontine neurons acts like sensory input from the body to the Thalamus. Overwhelming the rhythmic activity of the Thalamus and generating the EEG activity that is characteristic of REM sleep.
- These same Pontine neurons inhibit motor activity descending to the spinal cord, immobilizing the body.



LC – Locus Coeruleus; RN – Raphe Nuclei; PPT – Pedunculo Pontine Tegmentum; DLT – Dorsolateral Tegmental Area

Why do we Sleep?

Restorative Function:

- **What are we restoring?**

Adaptive Function:

- **Staying out of trouble?**

What induces SLEEP?

- Muramyl peptides – produced by bacteria
- Interleukin-1 – produced by glia and the immune system
- Adenosine – DNA/RNA/protein production, an increase induces sleep (which seems to happen the longer a subject is awake), antagonist of adenosine receptors keep people awake, Adenosine receptor activation inhibits the brainstem modulatory neurons.
- Melatonin – secretion of the Pineal Gland, derived from tryptophan, released when pineal gland is stimulated by darker environments (for humans information is gotten from visual input), levels rise to higher levels the later into the evening the body is active.