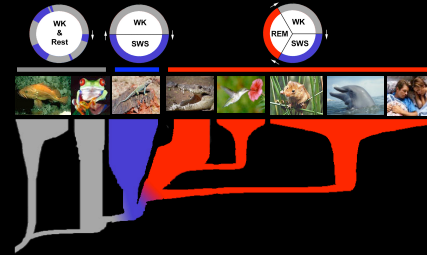


Neuronal reverberation, gene expression and the hippocampal exodus of memories during sleep



Sidarta Ribeiro  
Dept. Neurobiology - Duke University Medical Center

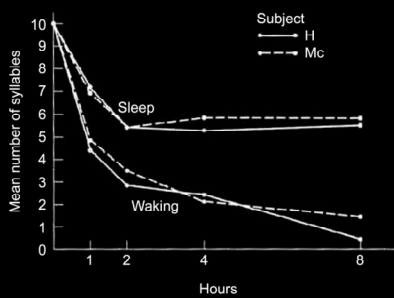
Evolution of the wake-sleep cycle in vertebrates



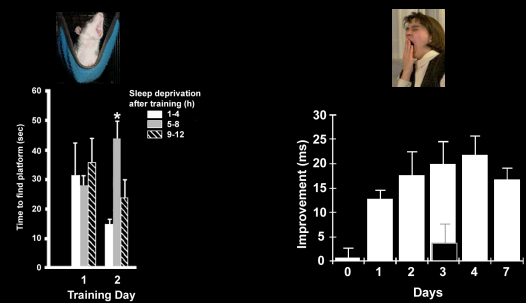
Biological Functions of sleep

- Energy conservation
- Replenishment of biomolecules used up during waking
- Processing and consolidation of new memories

Jenkins & Dallenbach, 1924



Sleep deprivation impairs learning



Smith and Rose, 1996

Stickgold et al., 2000

What are the mechanisms underlying memory consolidation during sleep?

Dual trace mechanism (Hebb, 1949)

Neuronal reverberation

Structural change

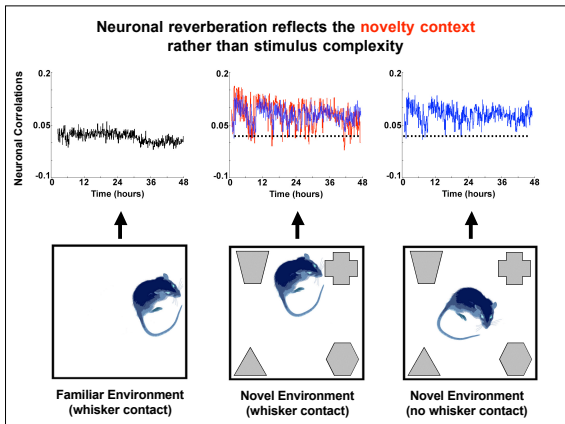
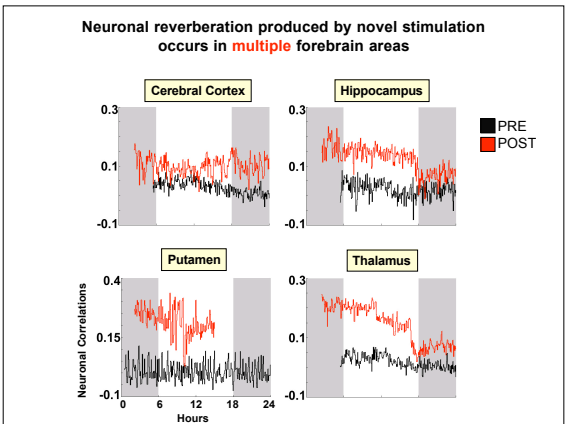
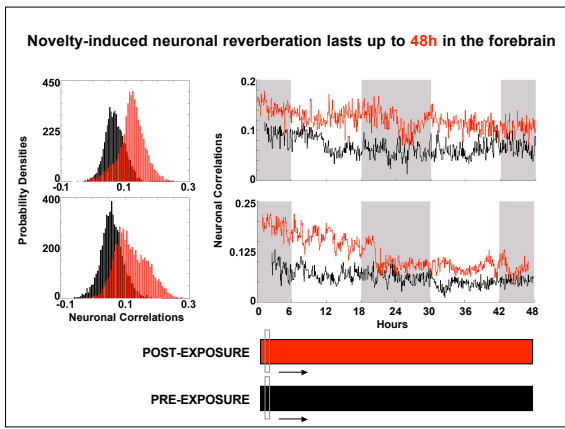
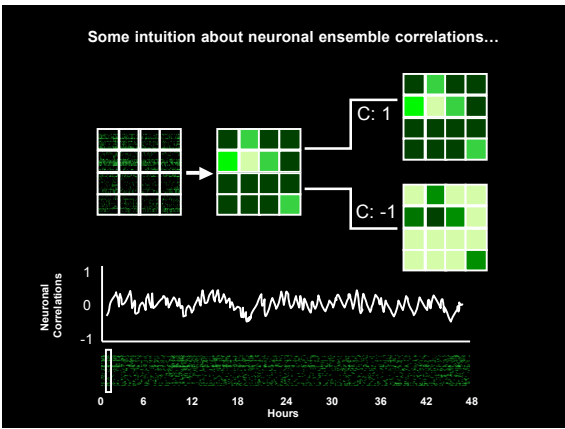
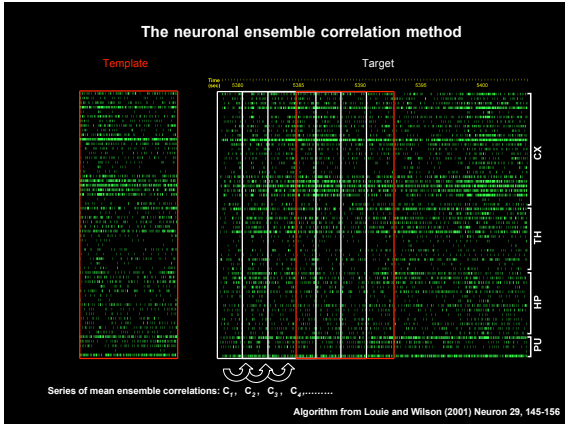
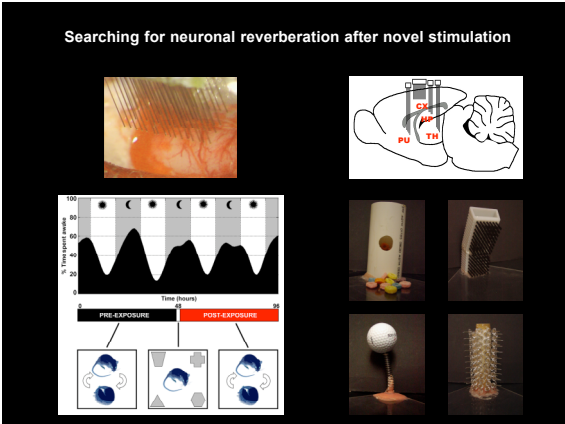
Dual trace mechanism

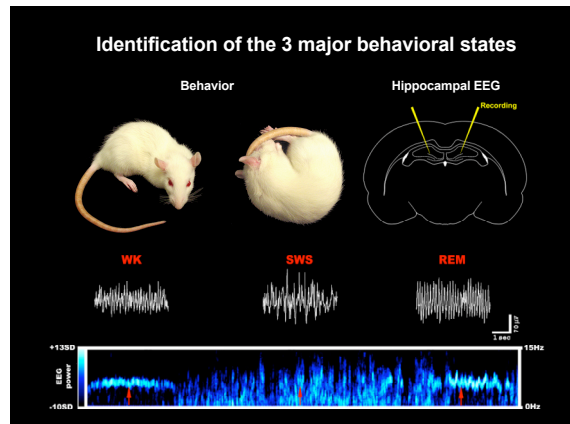
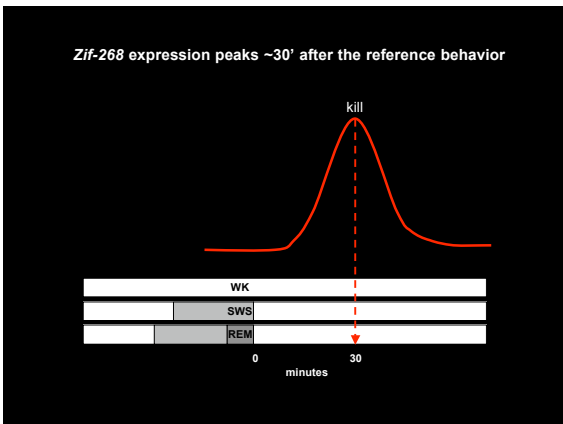
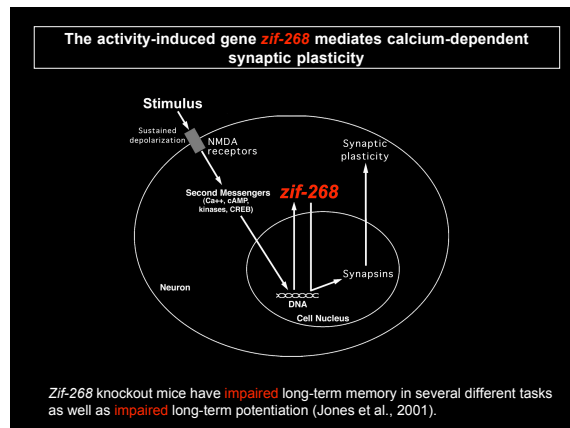
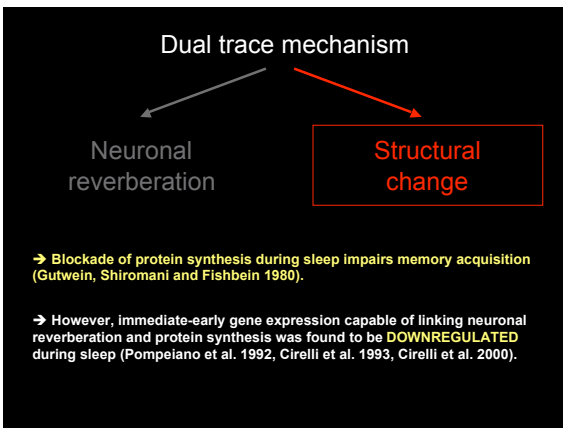
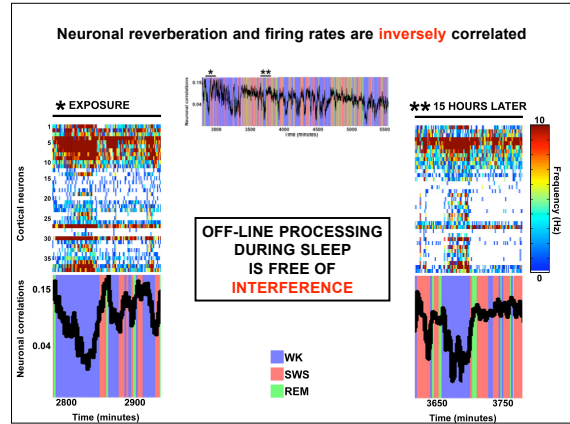
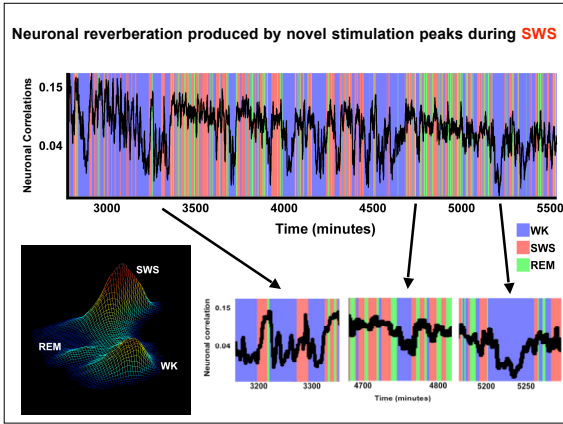
Neuronal reverberation

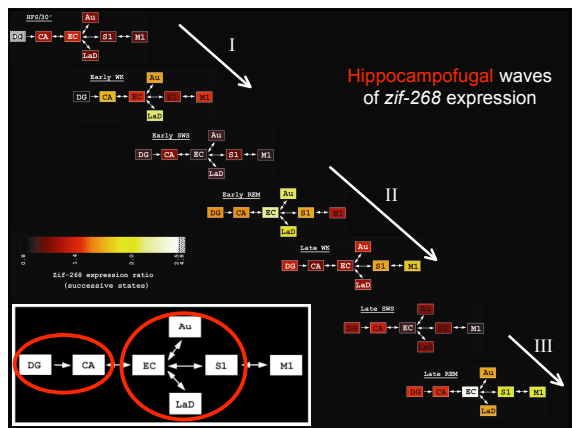
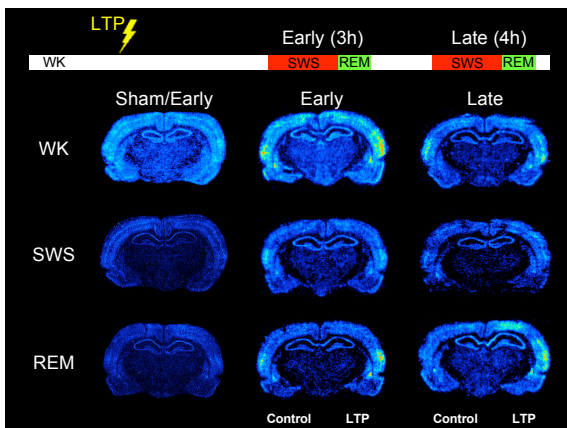
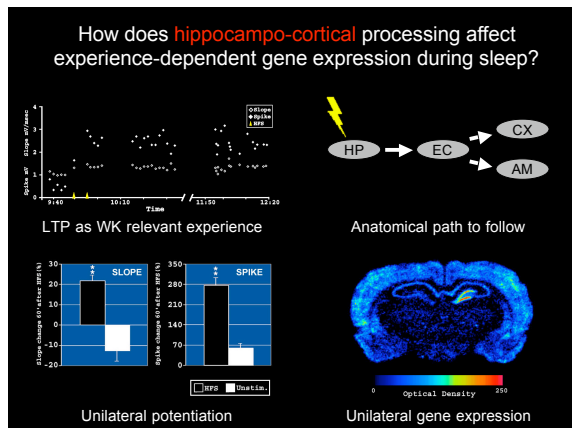
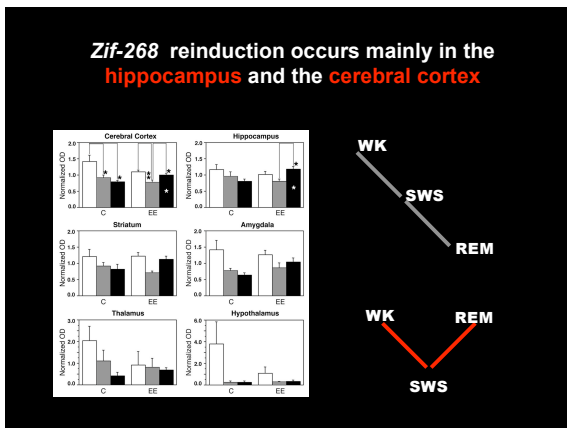
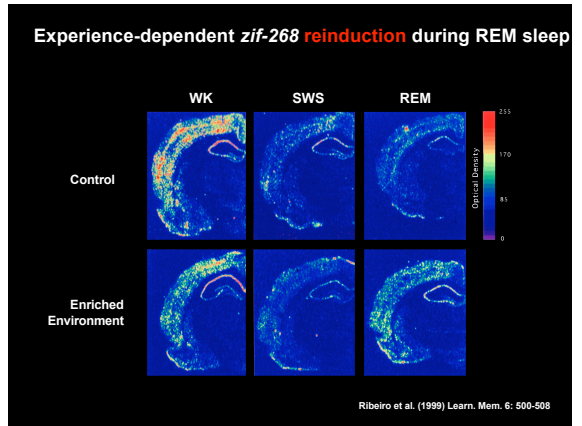
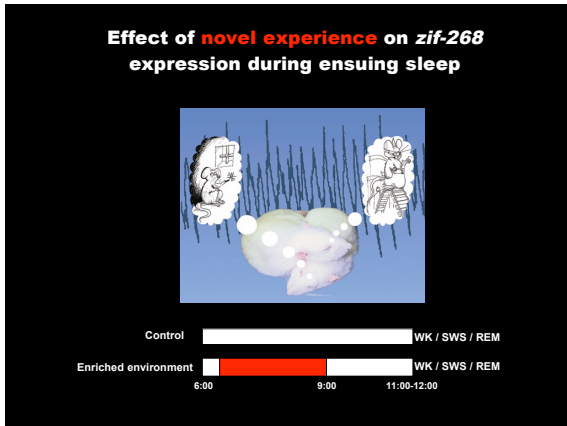
Structural change

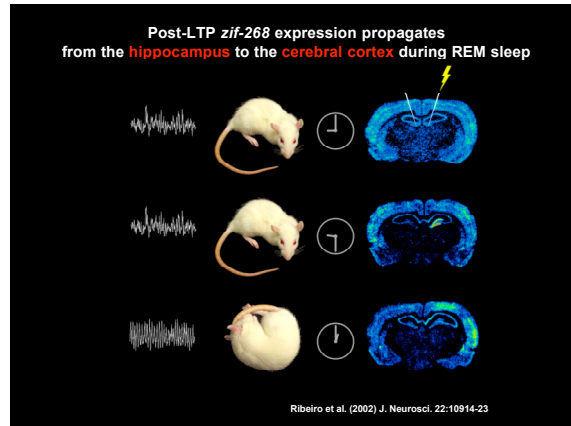
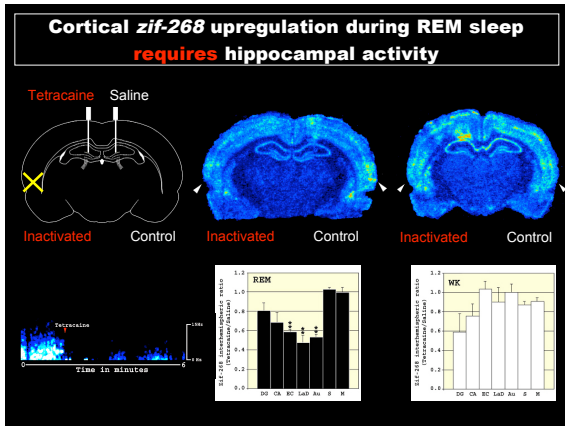
- WK hippocampal activity recurs during sleep (Pavlidis and Winson 1989).
- Reverberation observed in rats, songbirds and monkeys.
- Reverberation retains temporal signatures of previous WK activity.

**How late?** Less than 1h in CX (SW), perhaps 1 day in HP (REM)  
**Where?** Only investigated in the HP and CX  
**Which state?** Present in all states, but no quantitative comparison









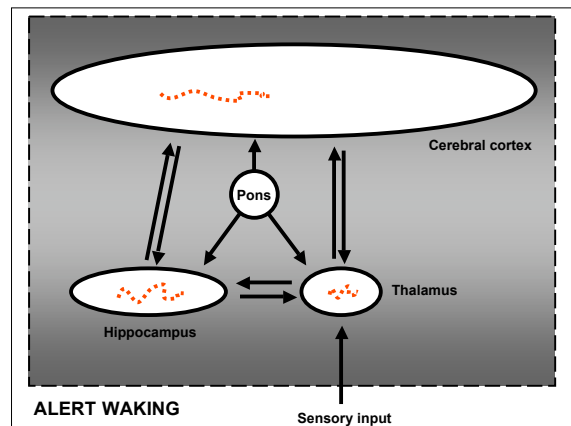
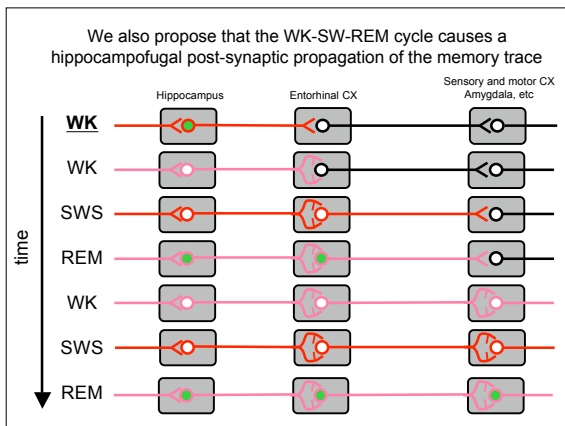
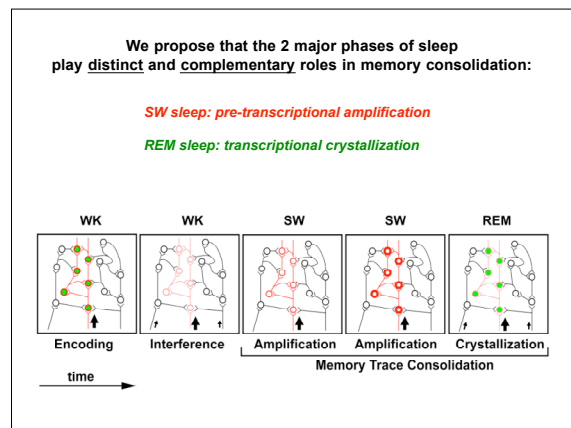
### Mechanism check-list for memory consolidation during sleep

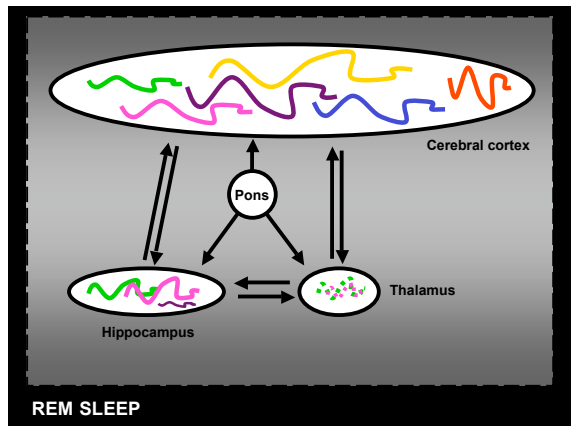
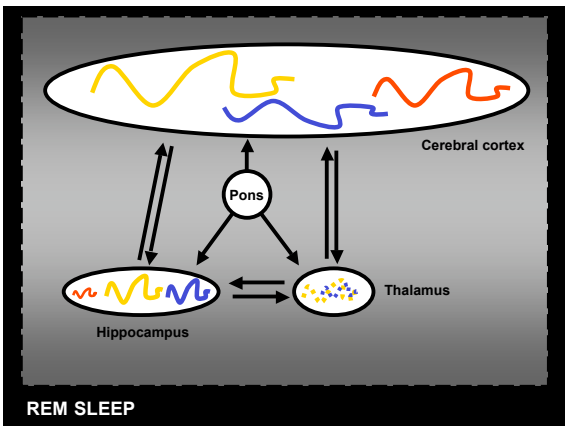
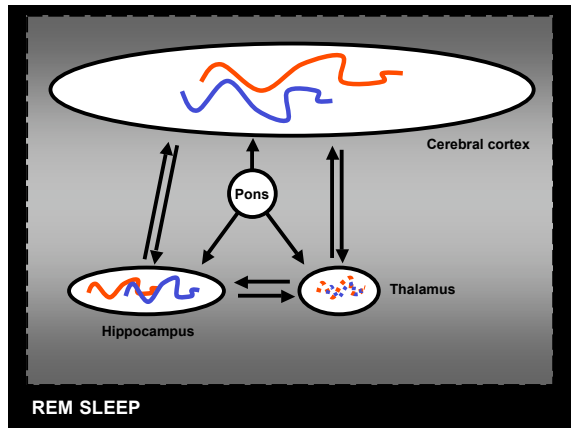
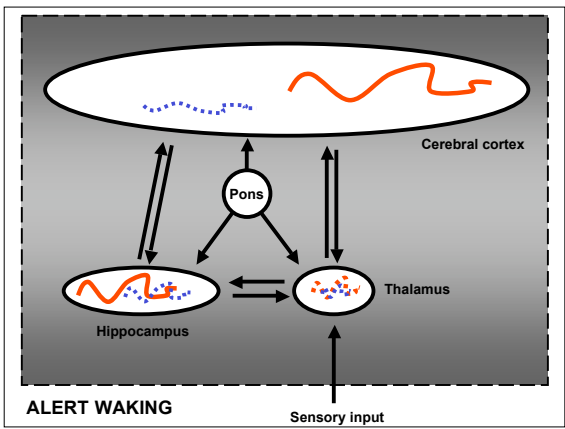
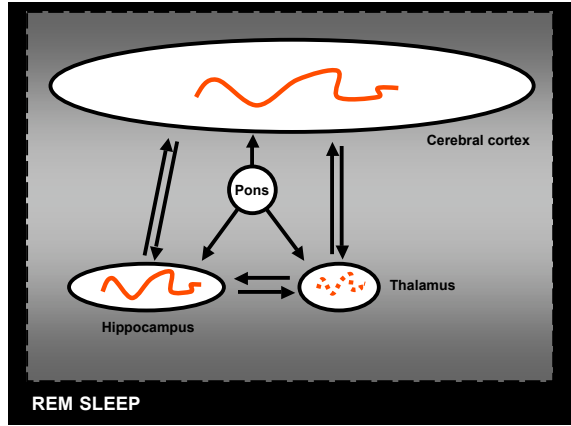
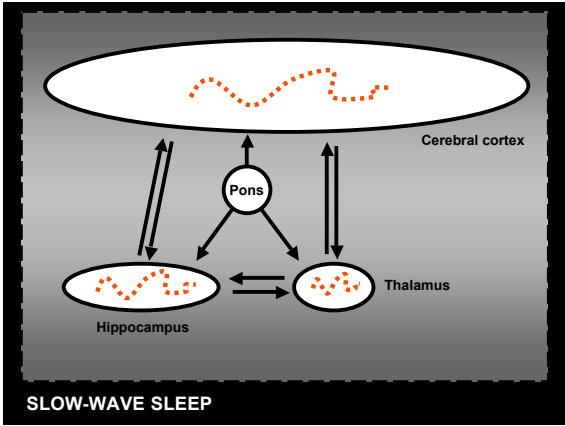
**Experience-dependent neuronal reverberation** ✓

Where? Hippocampus, cortex, thalamus and putamen ✓  
 How late? Sustained up to 48 hours ✓  
 Which state? Predominant during SWS ✓

**Plasticity-related gene expression during sleep** ✓

Where? Mainly hippocampus and cortex, not thalamus ✓  
 How late? At least up to 4 hours ✓  
 Which state? REM ✓





We speculate that:

\_ The WK-SWS-REM cycle promotes a **tidal migration** of memory traces within the forebrain.

\_ Due to the much larger coding capacity (e.g. # available synapses) of the cortex, such migration generates a net hippocampofugal flow of information that progressively **flushes** memory traces away from the hippocampus to the cerebral cortex.

### Electrophysiology

Miguel Nicolelis (Duke U)  
Damien Gervasoni (Duke U)  
Ernesto Soares (Duke U)  
Yi Zhou (Duke U)  
Shih-Chieh Lin (Duke U)  
Janaina Pantoja (Duke U)  
Michael Lavine (Duke U)

### Gene expression

Constantine Pavlides (RU)  
Claudio Mello (OHSU)  
Erich Jarvis (Duke U)  
Tarciso Velho (OHSU)  
Timothy Gardner (RU)  
Vikas Goyal (Harvard U)

Jonathan Winson



Professor Emeritus  
Rockefeller University

International Neurosciences Institute



Natal, Brazil  
2005



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