

Sleep and Brain Development

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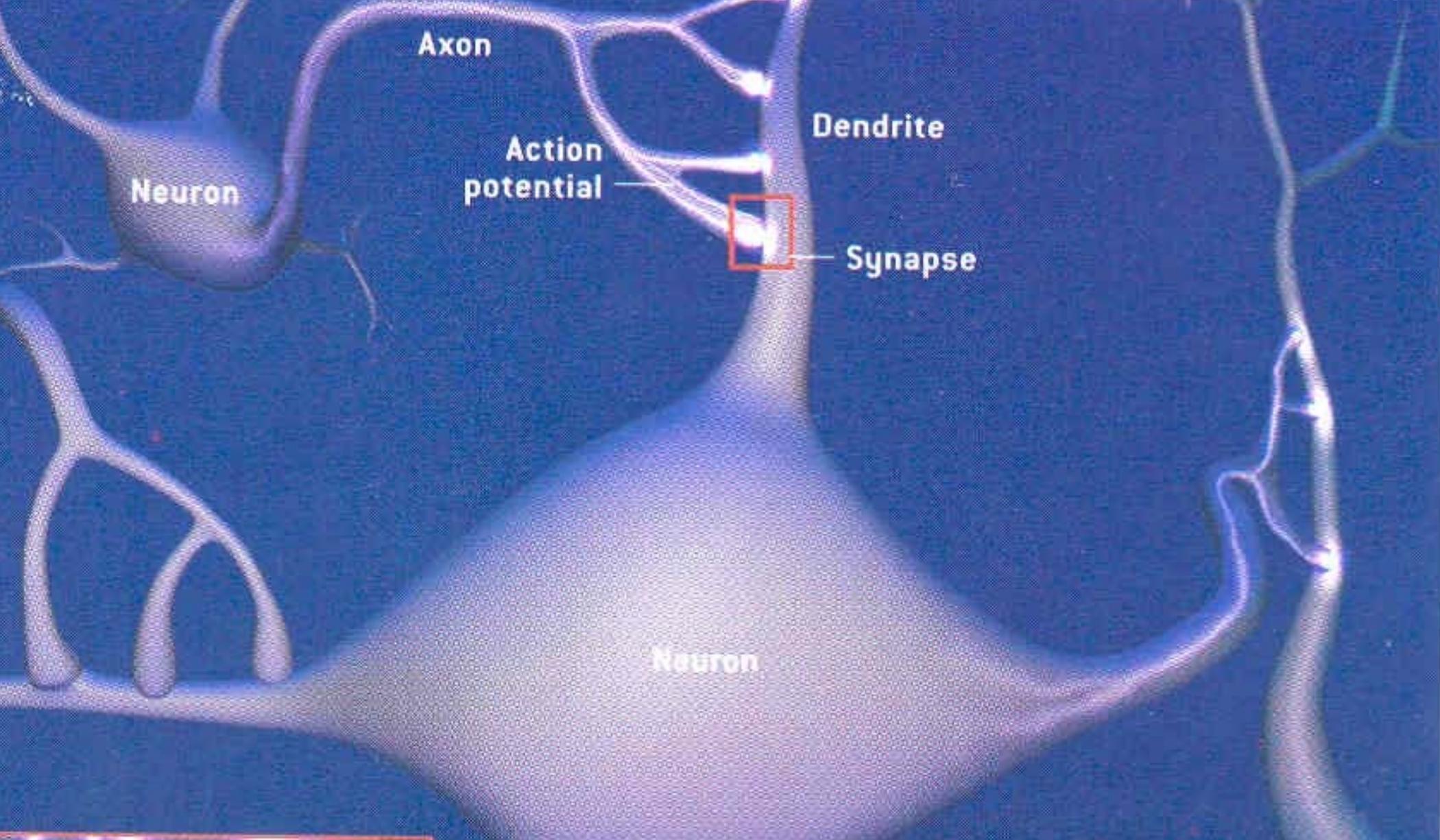
Creating Connections

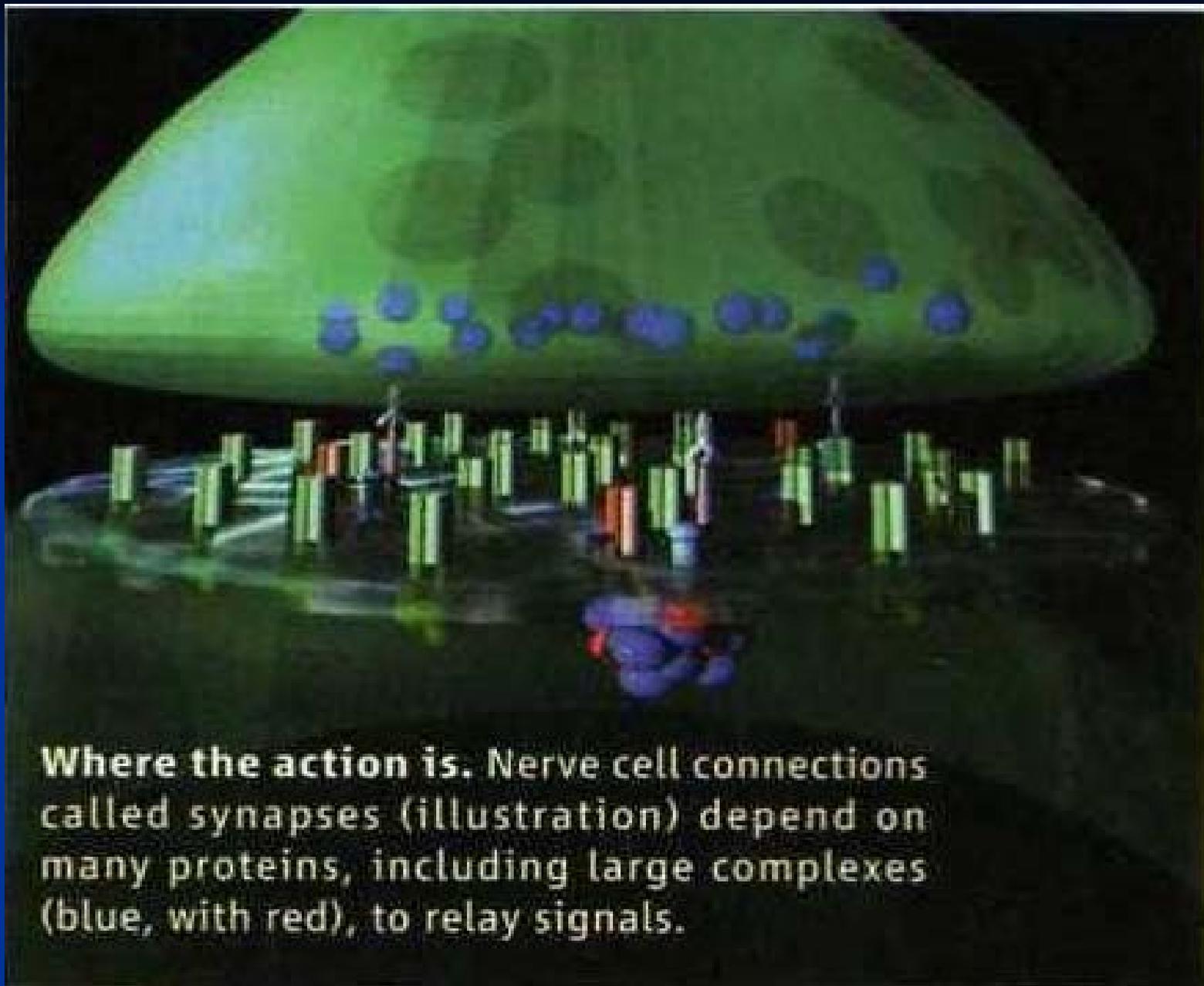
- The sensory stimulation or signal (vision, hearing, touch, smell, position, motion, feeling) creates the synapse or connection.
- Intensity and repetition determines duration.

Synapse Strengthen

Short term

- After a synapse fires briefly at high frequency it becomes more sensitive
- This results in greater voltage swing in response to subsequent signals
- The temporary strengthening of the synapse is the basis of short term memory





Where the action is. Nerve cell connections called synapses (illustration) depend on many proteins, including large complexes (blue, with red), to relay signals.

Duration

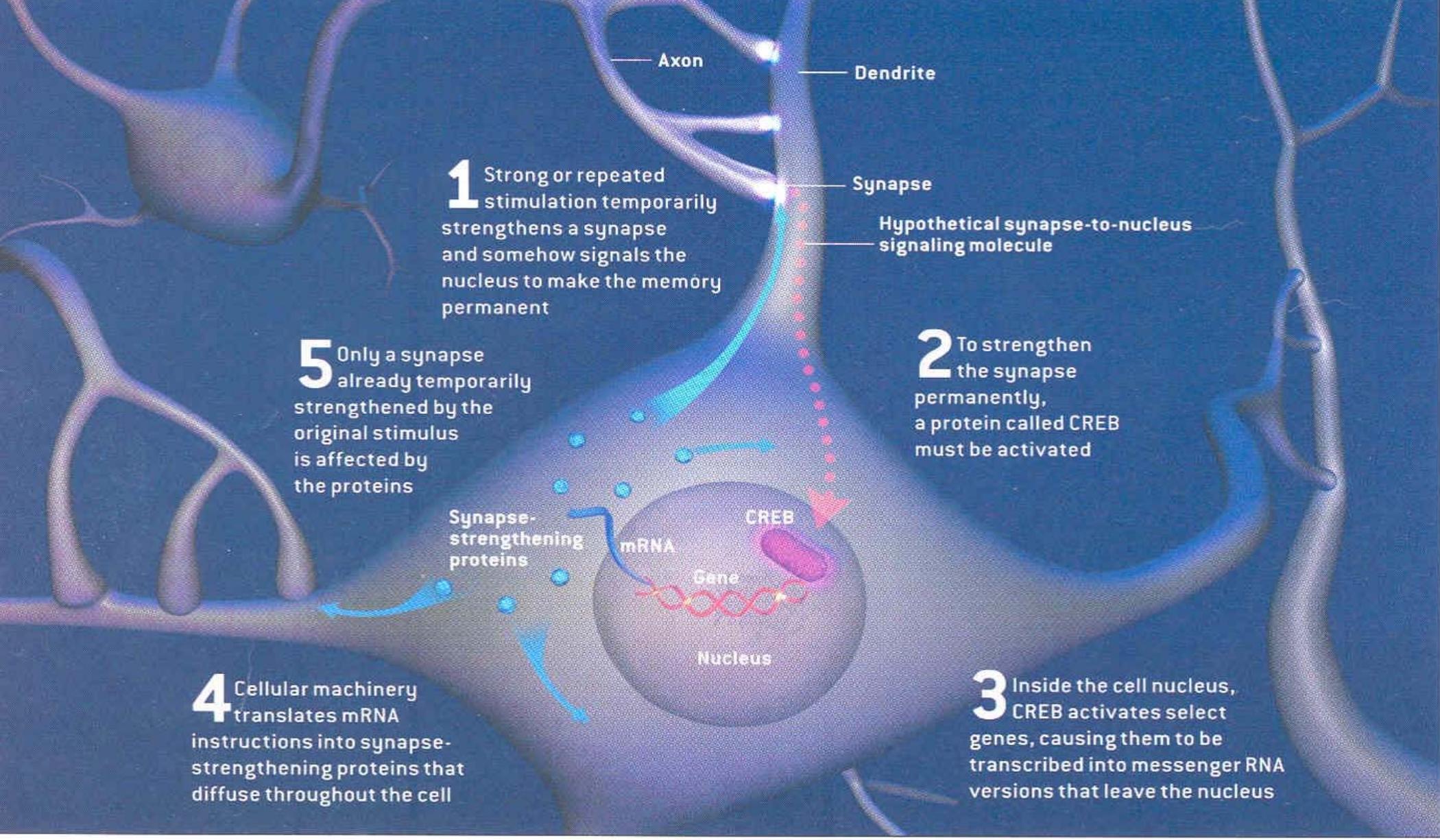
- For connection to be long term or permanent, the stimulus must be
 - 1) Clearly recognized
 - 2) Be repeated consistently
 - 3) Have time between groups of repetition
- The maintenance of the connection as permanent requires a genetic driven creation of a synapse specific protein.

Synapse Strengthening Permanently

- Strong stimulation of a neuron
 - 1) Repeated firing of a single synapse
 - 2) Simultaneous firing of several synapses
- Depolarizes the cell membrane causing the neuron to generate an action potential of its own
- The cell membrane opens calcium channels which interacts with enzymes which activate the transcription factor, CREB, in the nucleus

Synapse Strengthening *continued...*

- CREB activates genes for manufacturing synapse strengthening proteins
- The synapse strengthening proteins permanently strengthen the specific synapse or synapses.
- This creates a permanent memory.



1 Strong or repeated stimulation temporarily strengthens a synapse and somehow signals the nucleus to make the memory permanent

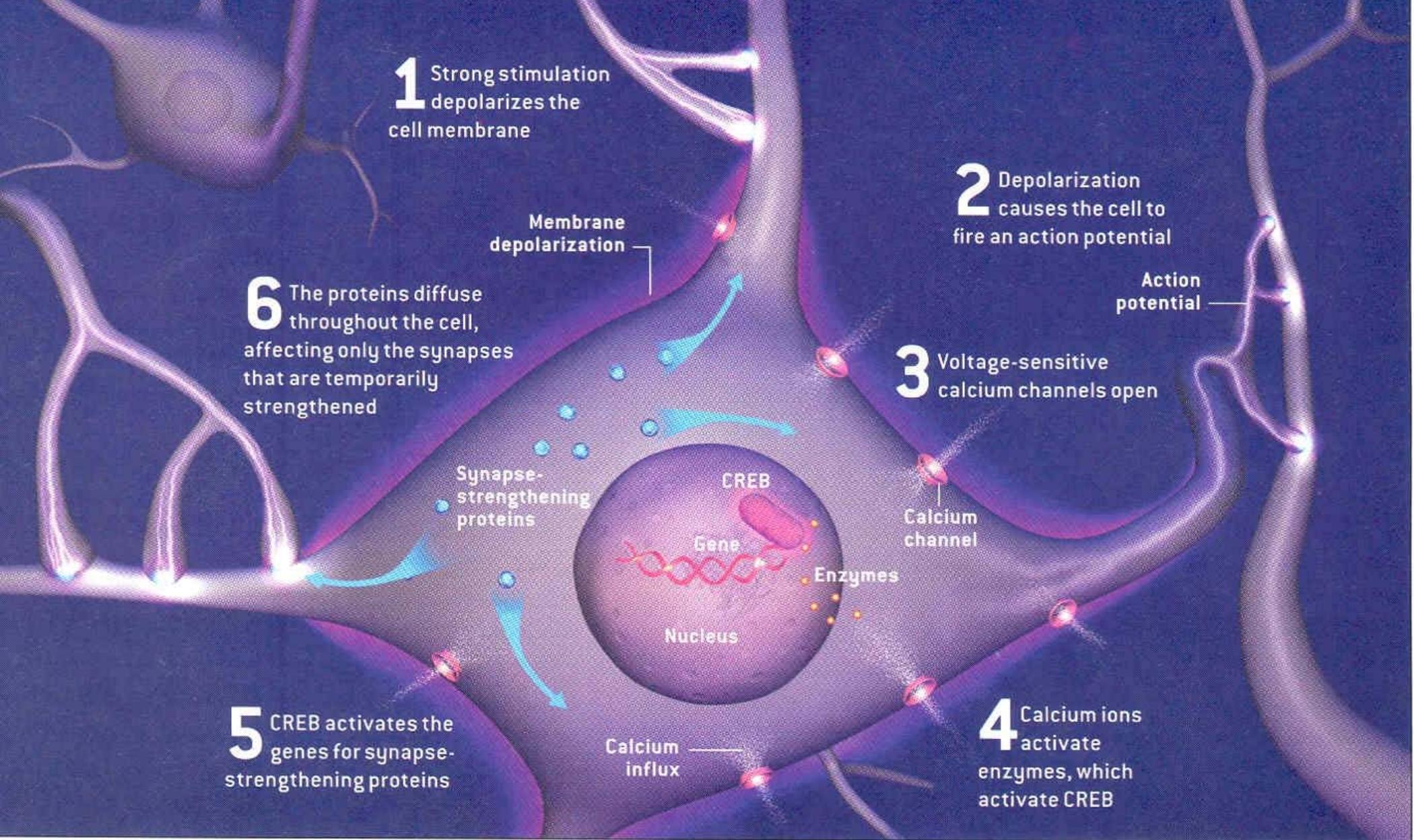
2 To strengthen the synapse permanently, a protein called CREB must be activated

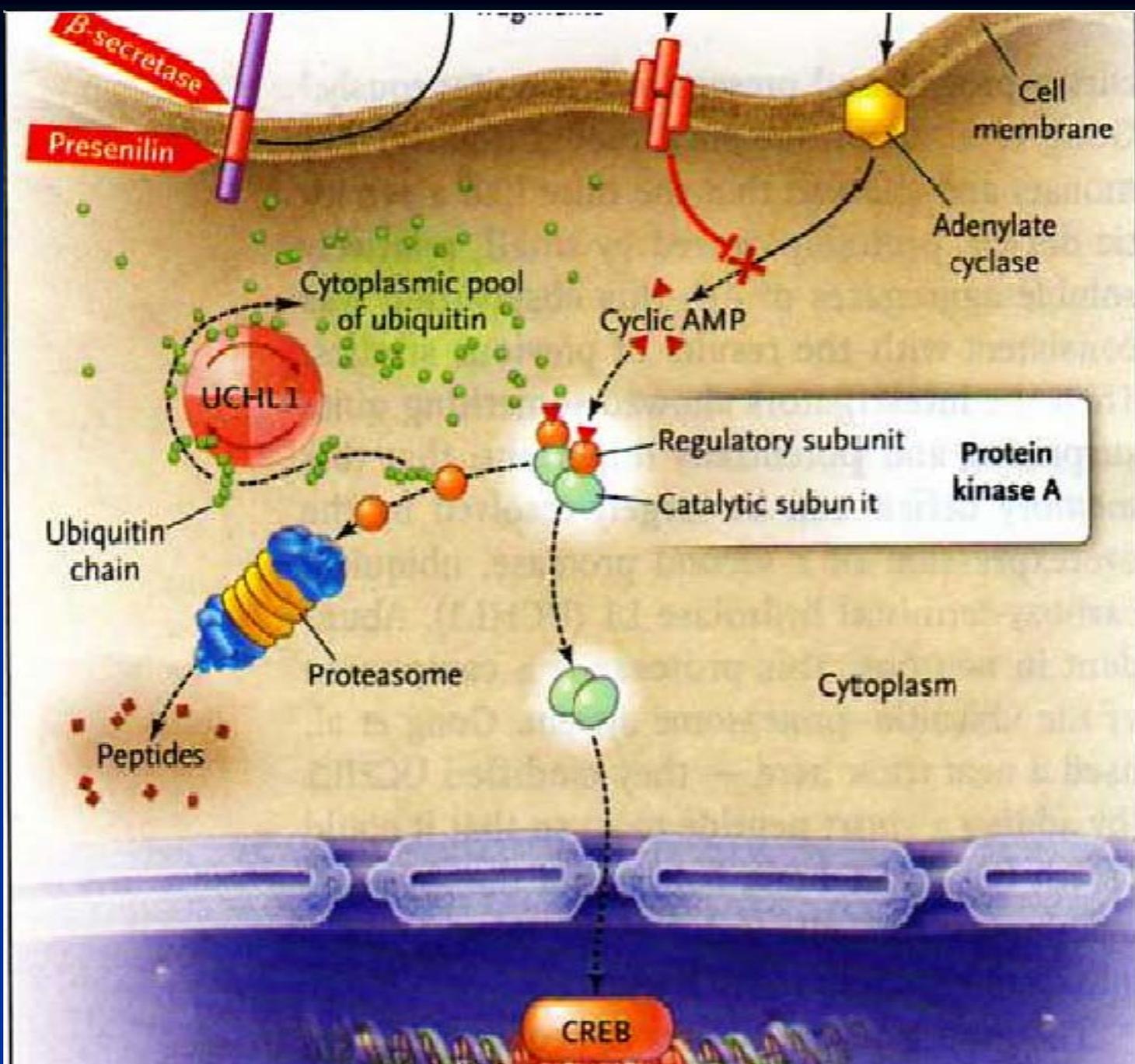
3 Inside the cell nucleus, CREB activates select genes, causing them to be transcribed into messenger RNA versions that leave the nucleus

5 Only a synapse already temporarily strengthened by the original stimulus is affected by the proteins

4 Cellular machinery translates mRNA instructions into synapse-strengthening proteins that diffuse throughout the cell

Synapse-strengthening proteins







Sleep Studies

1. Sleep behaviors
2. EEG recording
3. Continuous EEG recording
4. Functional brain imaging
5. Animal models- single cell and cell group activity recording

Sleep and Brain Development

Principles and Concepts

A. Sleep

1) Sleep is not a time of brain rest or quiet time.

2) Sleep is a time of brain activity. The brain of an infant or child is more active during some stages of sleep than it is during wakefulness and awake activities.

3) Sleep is stimulated to begin- an active process.

Role of REM and NREM Sleep Cycles

1. Neurosensory development
2. Preservation of brain plasticity
3. Learning and long term memory

Sleep and Brain Development

Principles and Concepts

B. Learning

1) The brain is designed very well to *NOT* remember. Most of what we see, hear, touch, smell or feel does not stay as a memory. It is 'sensory noise' and as a memory disappears or is not formed.

Sleep and Brain Development

Principles and Concepts

B. Learning

2) To create long term memory and learning the sensory input (vision, learning, touch, smell, feeling) must:

- a) Occur when the child is awake and attentive.
- b) Be unique, important and focused.
- c) Stand out from the background, be discernable.
- d) Occur when there is not a lot of distraction.
- e) Have feeling and meaning attached.

Sleep and Brain Development

Principles and Concepts

B. Learning

3) There is no single or simple all purpose memory storage area.

4) Any image or piece of knowledge has multiple sites of representation in the brain. It is stored in multiple sites. Each site corresponds to a different meaning or use. Most images have an attachment to feelings or emotions.

Sleep Stages

Non-REM Sleep

Stage 1- Drowsy or sleep onset

Stage 2- Light sleep

Stage 3- Deep sleep (slow wave sleep)

Stage 4- Deeper sleep (slow wave sleep)

REM Sleep

Restless sleep- paradoxical sleep

Characteristics of NREM Sleep

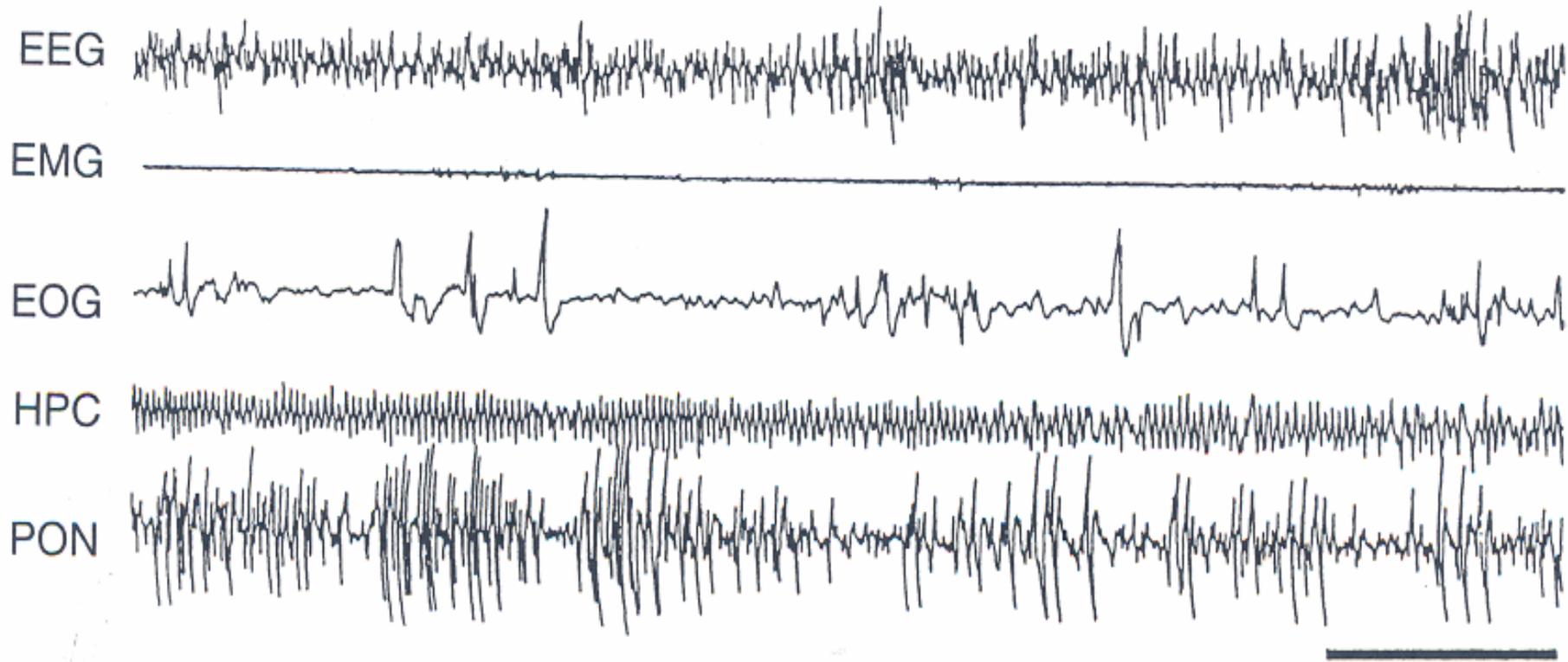
Slow Wave Sleep

1. Quiet- little muscle movement
2. Few eye lid movements
3. Slow wave EEG pattern
4. Different depths of sleep

Characteristics of REM Sleep

1. REM's Rapid eye lid movements
2. Muscle twitches but trunk muscle atonia by 2-3 months
3. Desynchronous cortical EEG
4. P waves from Pons
5. Theta waves from hippocampus
6. Dreams occur

REM Sleep



Sleep Cycles

1. Sleep is essential for building the sensory systems of the brain from 28 wks. Gestation to 3-5 months of age.
2. Sensory systems require REM sleep specifically for early development.
3. Sleep occurs in cycles of REM and Non REM (deep or quiet sleep) between periods of wakefulness or drowsy sleep.
4. Sleep cycles start before birth and continue for the lifetime of the individual.

Role of REM and NREM Sleep Cycles

1. Neurosensory development
2. Preservation of brain plasticity
3. Learning and long term memory

Systems Dependent on REM Sleep for Development

1. Visual system
2. Auditory system
3. Touch system
4. Olfactory system (smell)
5. Limbic system (emotional experience)
6. Hippocampal system (memory creation)
7. Pons, thalamus and brain stem centers

NREM- REM Sleep Cycles

2. Preservation of brain plasticity

“Brain plasticity refers to the ability of the brain to persistently change its structure and function in response to environmental changes and needs.”

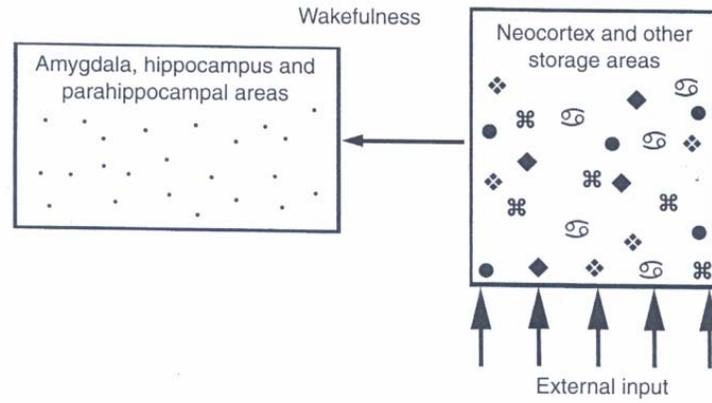
This operates over the lifetime of the individual-
requires both NREM and REM sleep.

NREM- REM Sleep Cycles

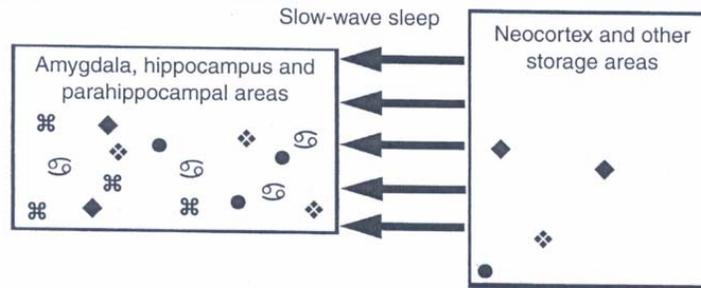
3. Learning and Memory Development

- (a) Acquisition phase- wakefulness (awake time)
- (b) Preconsolidation- NREM sleep
- (c) Consolidate, organize and form long term memory- REM sleep
- (d) Create cue's for memory recall

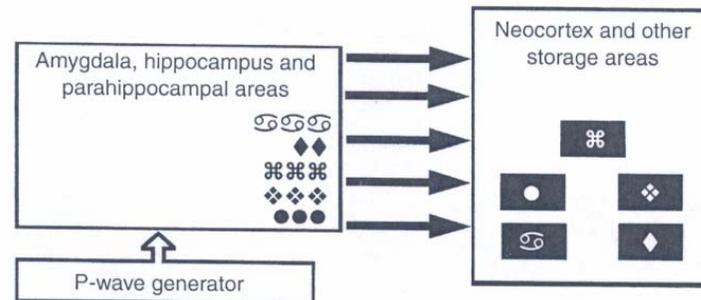
Acquisition

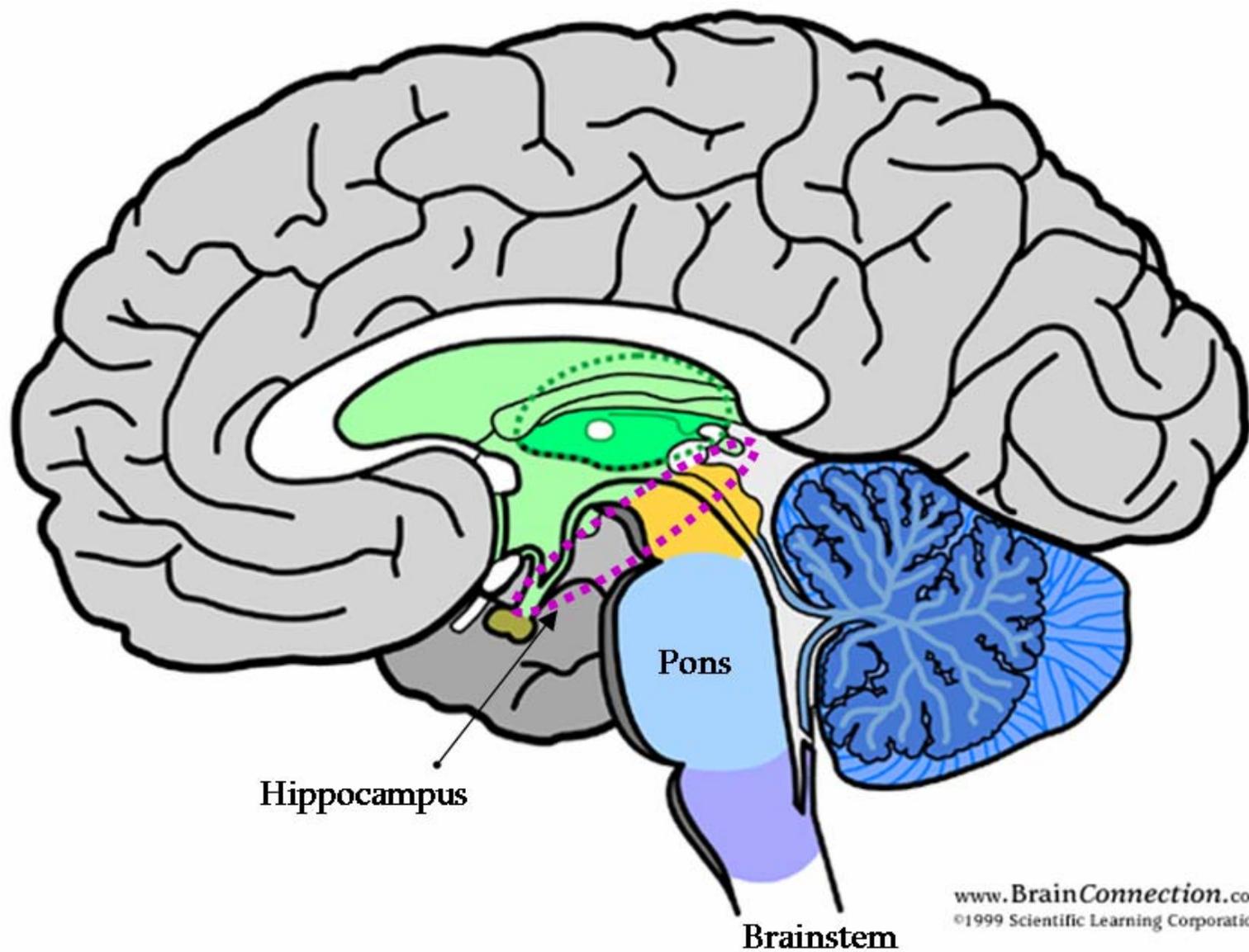


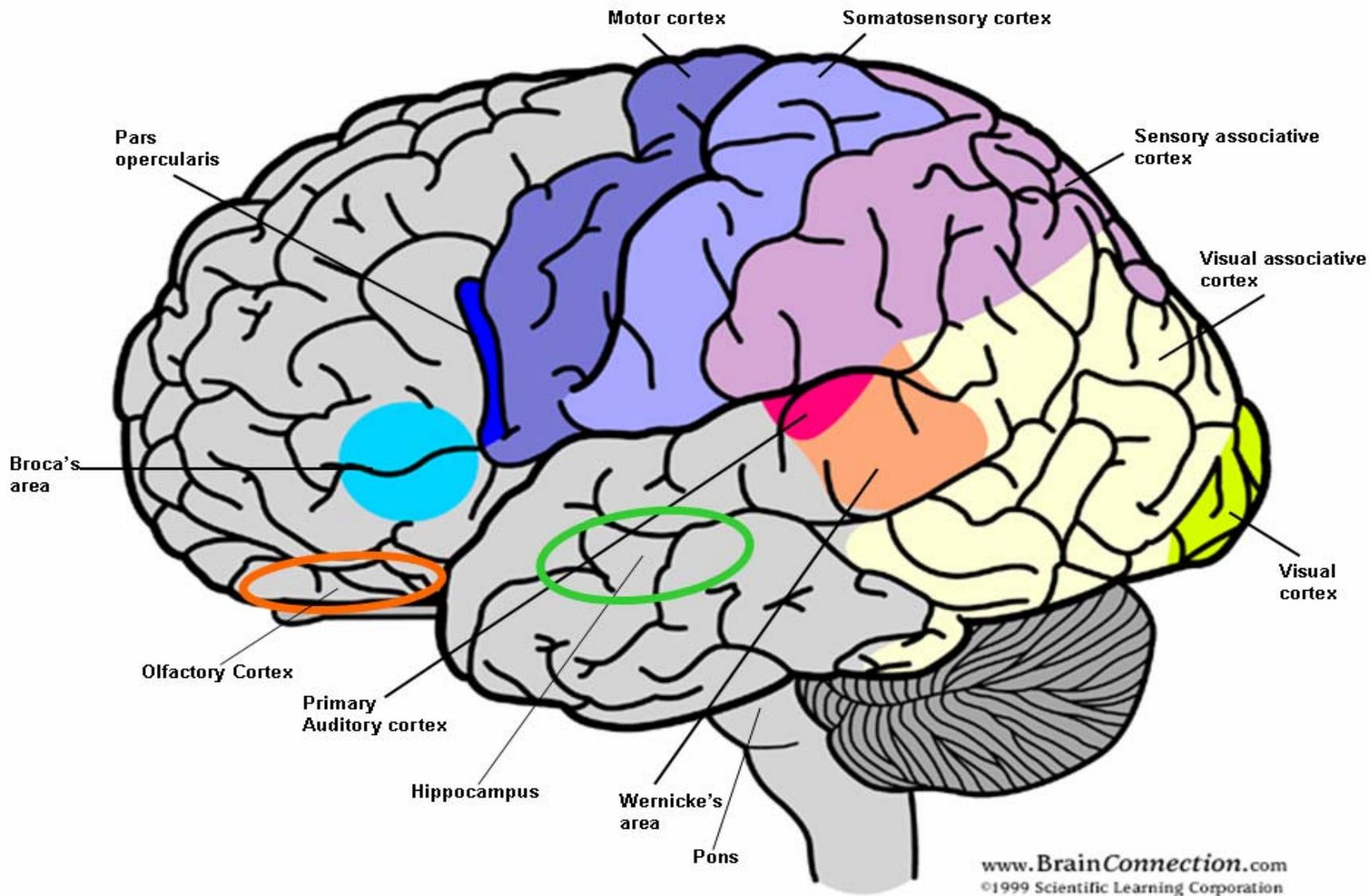
Pre-consolidation (Elimination of noise)

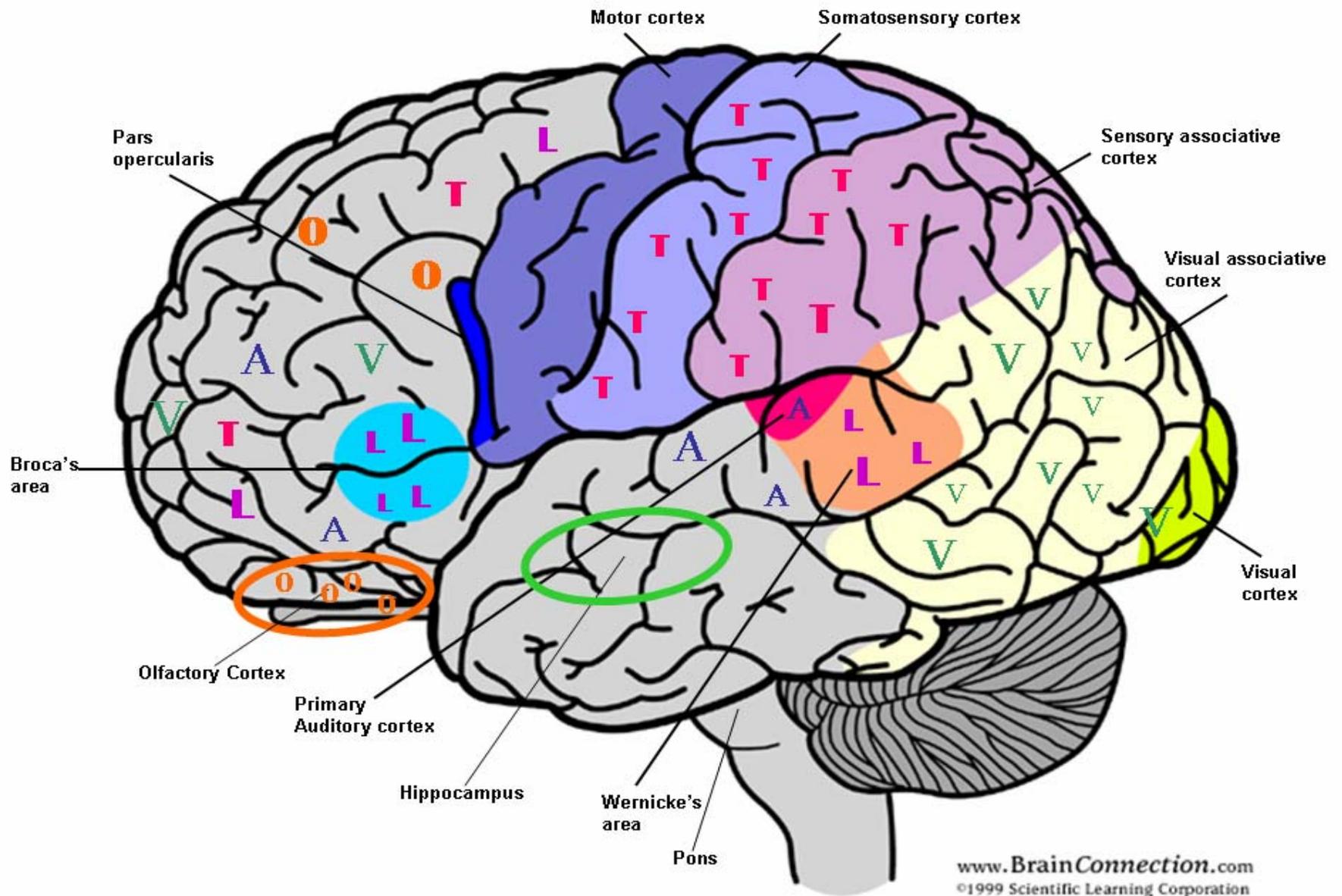


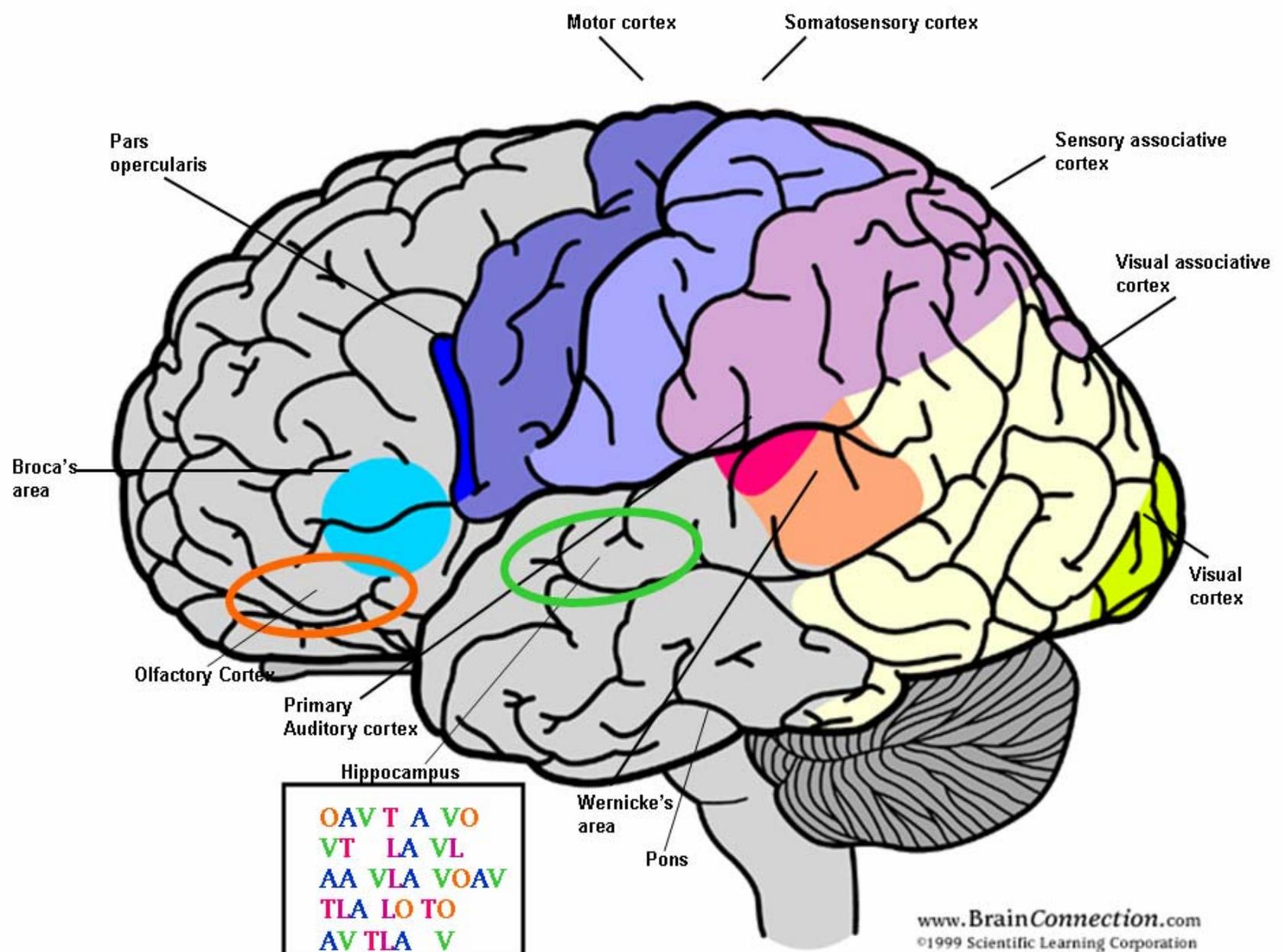
Consolidation and long-term storage



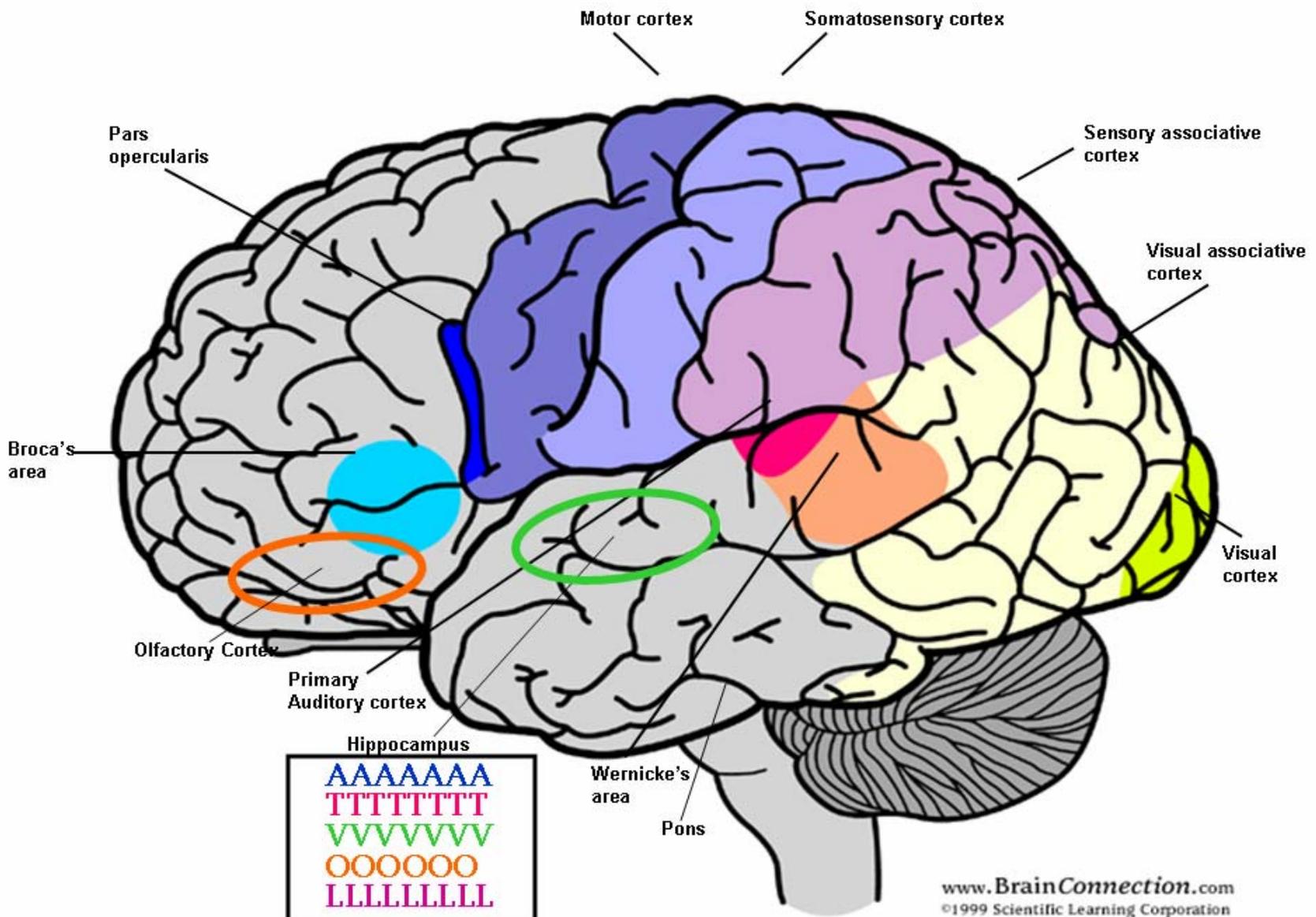


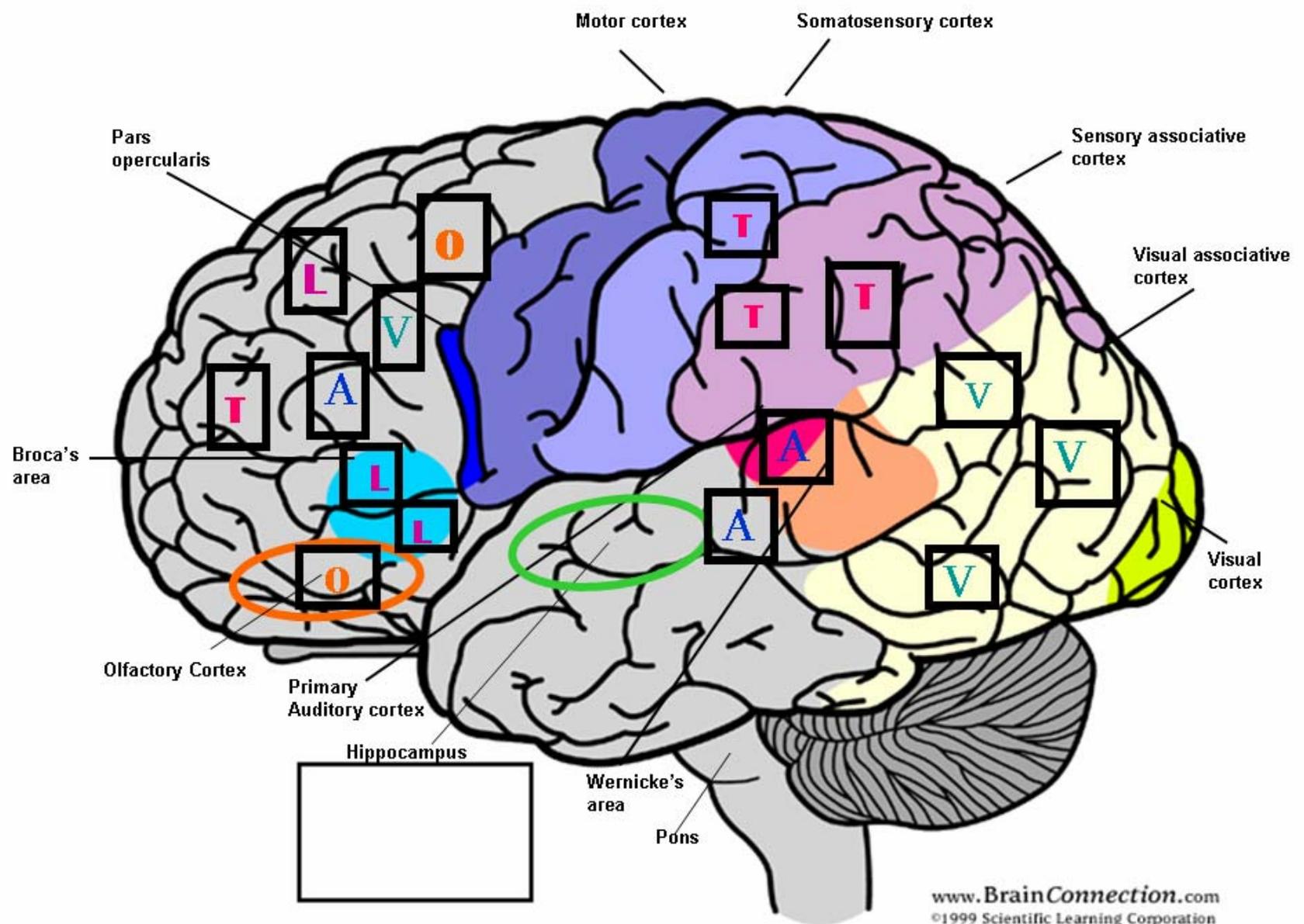




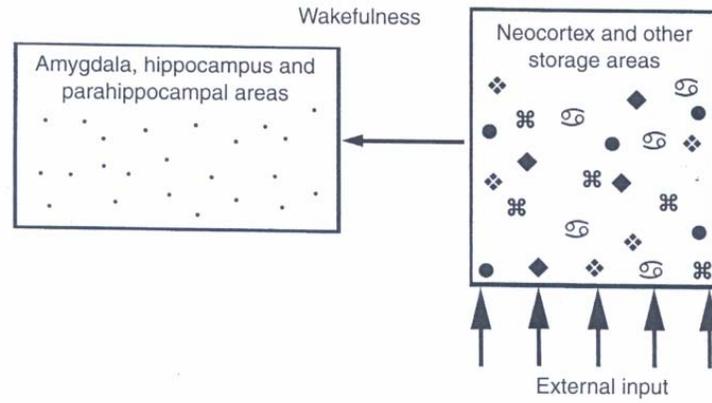


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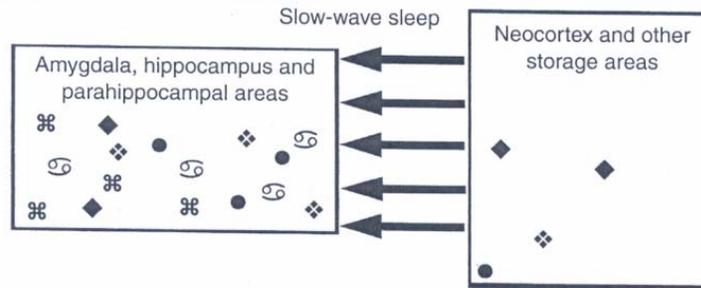




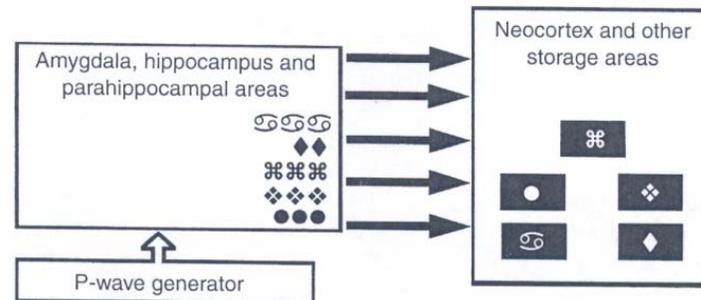
Acquisition



Pre-consolidation (Elimination of noise)



Consolidation and long-term storage



REM Sleep Deprivation

REM sleep deprivation results in:

1. Disordered sensory system- infants
2. Disordered or disrupted learning and memory creation
3. Loss of cortical plasticity into adult life
4. Smaller adult brain size

Non REM Sleep Deprivation

Non REM sleep deprivation results in:

1. Decreased learning and memory consolidation from sensory experiences (vision, hearing and touch).
2. Less ability to learn in childhood and adult life.
3. Loss of brain plasticity into adult life.
4. Smaller adult brain size.

Critical Components of Sleep Cycle

1. Wakefulness

- (a) Meaningful, appropriate sensory experience
- (b) Focus, attention, interest
- (c) Supportive emotional environment
- (d) Absence of conflicting stimuli or excess sensory noise

Critical Components of Sleep Cycle

2. NREM Sleep (Quiet sleep)

- (a) Cortical slow wave activity
- (b) Hippocampus waves
- (c) Decreased activation of sensory system
- (d) Avoid noise, movement and touch/pain

Critical Components of Sleep Cycle

3. REM Sleep

- (a) Desynchronous cortical waves
- (b) REM's
- (c) Pons generated P waves and PGO waves
- (d) Hippocampus theta waves
- (e) Decreased activation of sensory system
- (f) Avoid noise, movement and touch/pain

Sleep and Memory

1. Sleep essential for development of sensory systems- infants.
2. Sleep is essential for learning and memory.
3. Sleep is essential for preservation of brain plasticity and capacity for future learning.