



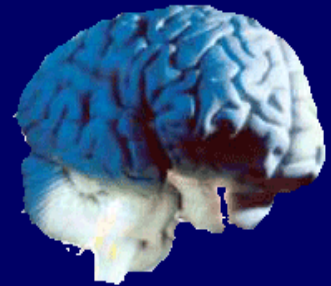
# Consciousness and neurobiology

**M.Drobný<sup>1</sup> . B.Sániová<sup>2</sup>**

Clinic of Neurology<sup>1</sup>, Jessenius Faculty of Medicine and Faculty Hospital in Martin; Clinic of Anaesthesiology and Intensive Medicine<sup>2</sup> Jessenius Faculty of Medicine Faculty Hospital in Martin, Slovak Republic, Europe

# Consciousness

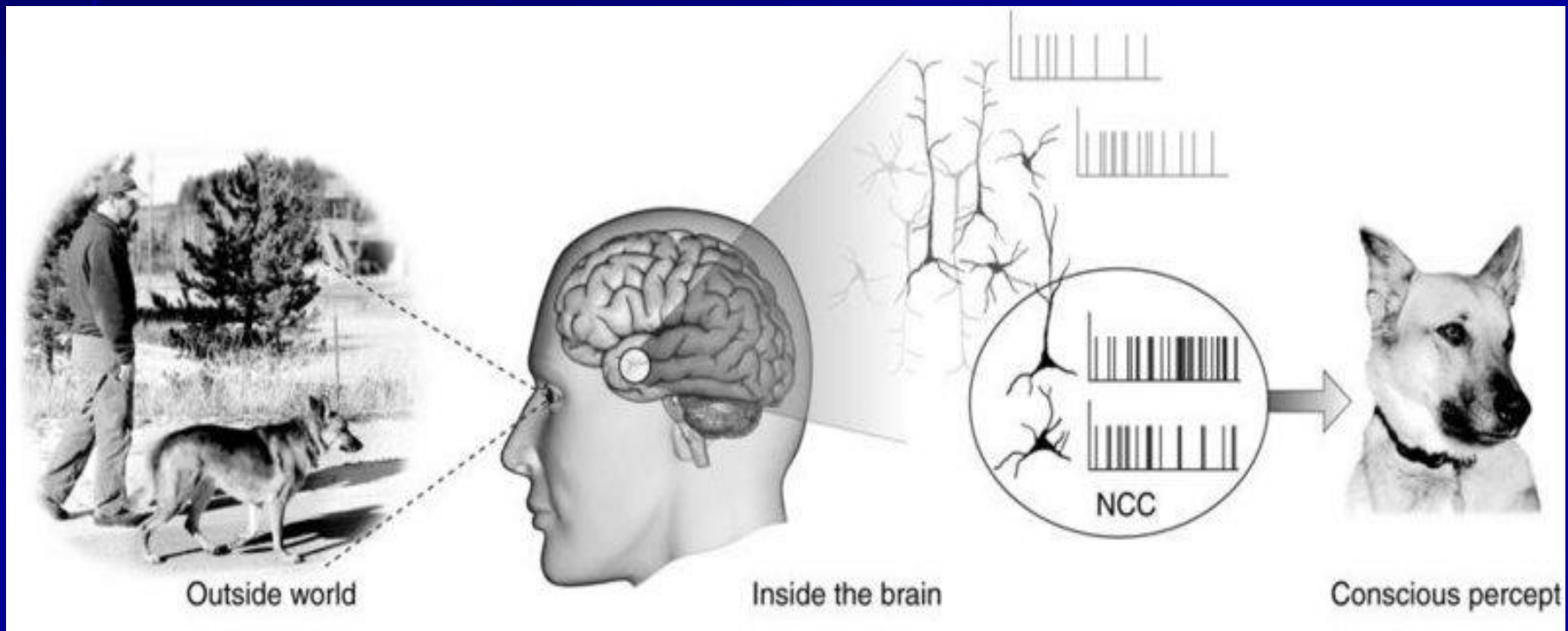
## Description



- Consciousness is one of the principal properties of the human brain a highly evolved system; it must therefore have a useful function to perform (Crick and Koch, 1992,1995).



**The Neuronal Correlates of Consciousness (NCC) are the minimal set of neural events and structures – here synchronized action potentials in neocortical pyramidal neurons – sufficient for a specific conscious percept or conscious (explicit) memory. From Koch (2004).**



# Consciousness



- **Crick and Koch (1995a)** suggested, that the biological usefulness of visual consciousness in humans is to produce the best current interpretation of the visual scene in the light of past experience,

# Consciousness



- **Consciousness** is a quality of the mind generally regarded to comprise qualities such as subjectivity, self-awareness, sentience, sapience, and the ability to perceive the relationship between oneself and one's environment.

# Consciousness



The term '**consciousness**' is explained as:

- **“ the state of being conscious; awareness of one’s own existence, sensations, thoughts, surroundings, etc.”** (Anonymous, 1989).

# Consciousness

## Description



- **Consciousness is a puzzling state dependent property of certain types of complex, adaptive systems.**
- **The best example of one type of such system is a healthy and attentive human brain.**

# Consciousness



is a state that defies definition, but which may involve:

- thoughts, sensations, perceptions, moods, emotions, dreams, **and**
- an awareness of self, **although not necessarily all of these**

# Consciousness



**either of ourselves or of our ancestors (embodied in our genes), and to make this interpretation directly available, for a sufficient time, to the parts of the brain that contemplate and plan voluntary motor output, of one sort or another, including speech.**

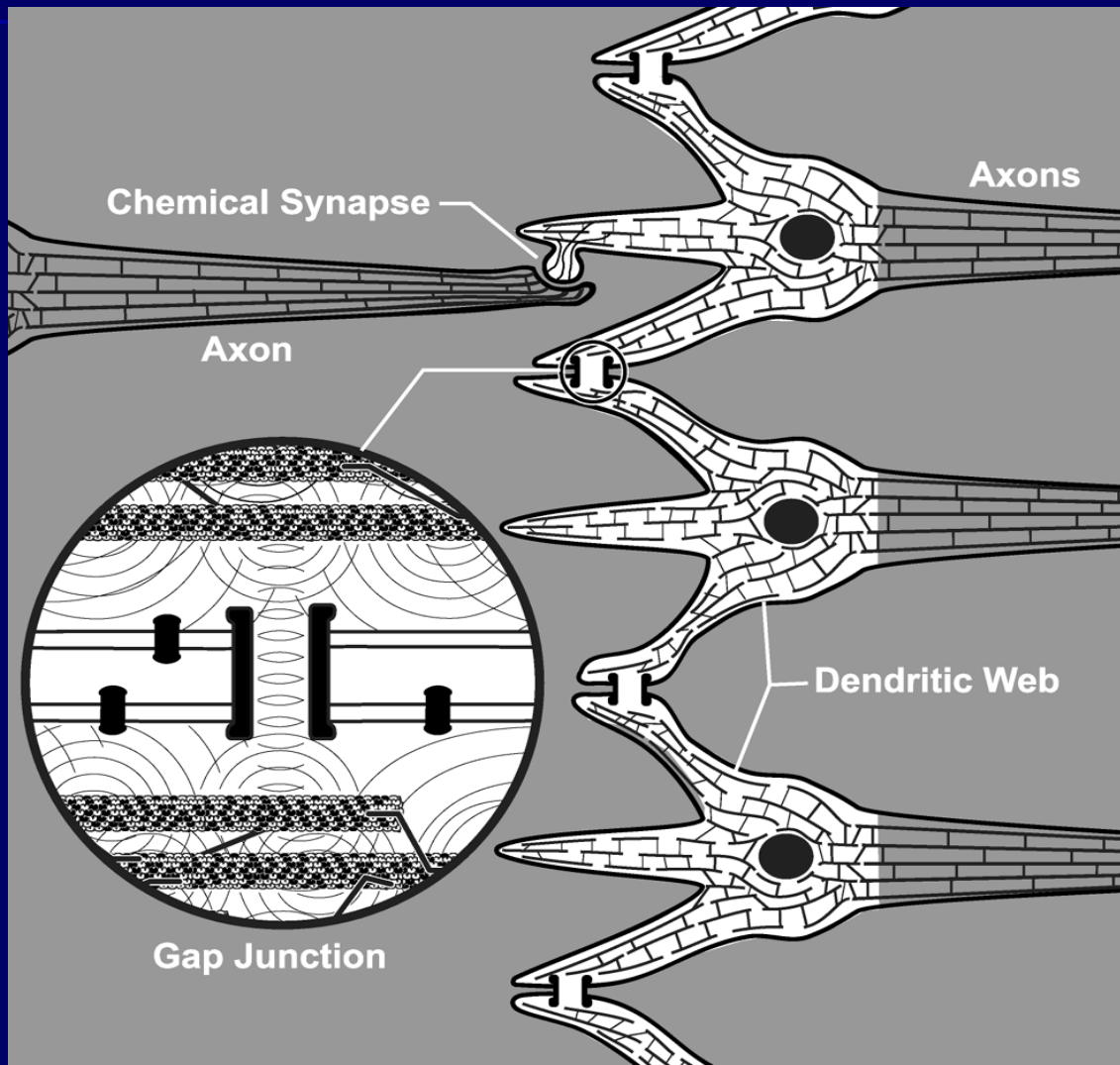


# **Consciousness**

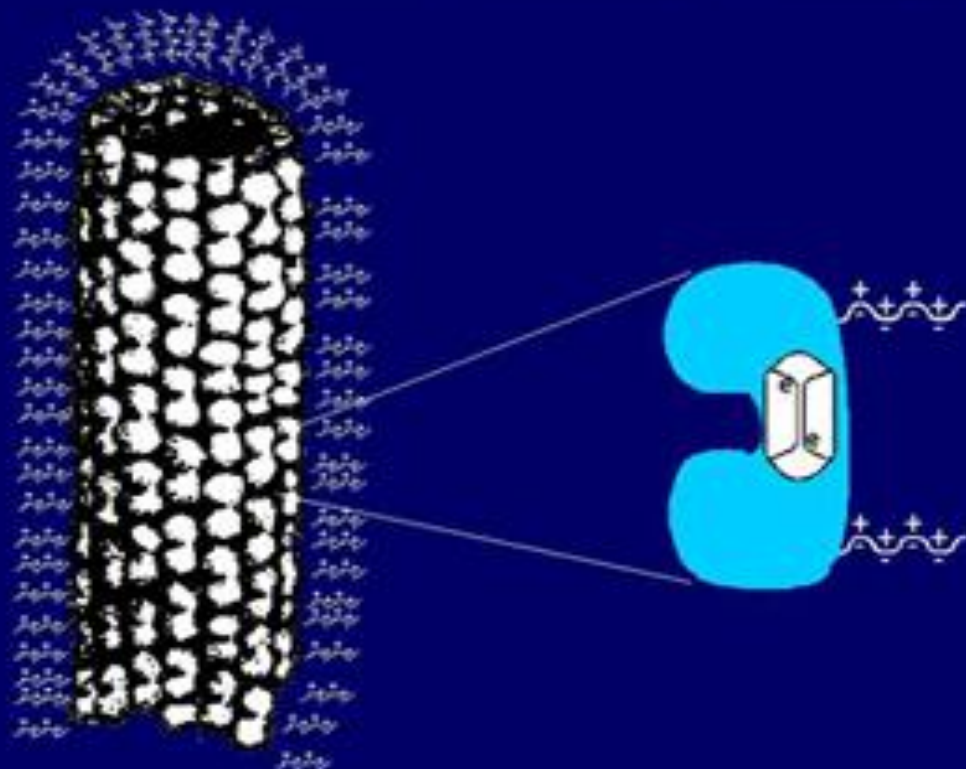
**Up-to-date neurobiologic definition**

**Consciousness occurs in dendrites of cortical neurons interconnected by gap junctions, forming Hebbian „hyperneurons“ synchronizing in 40Hz gamma band frequency.**

**Consciousness occurs in dendritic web interconnected by gap junctions, forming Hebbian cortical hyperneurons. Axonal spikes convey inputs and outputs from the „web“(S. Hameroff, Springer, 2007)**



***Dan Sackett at NIH recently described a plasma-like sleeve of charged ions surrounding microtubules at precisely optimal pH.***



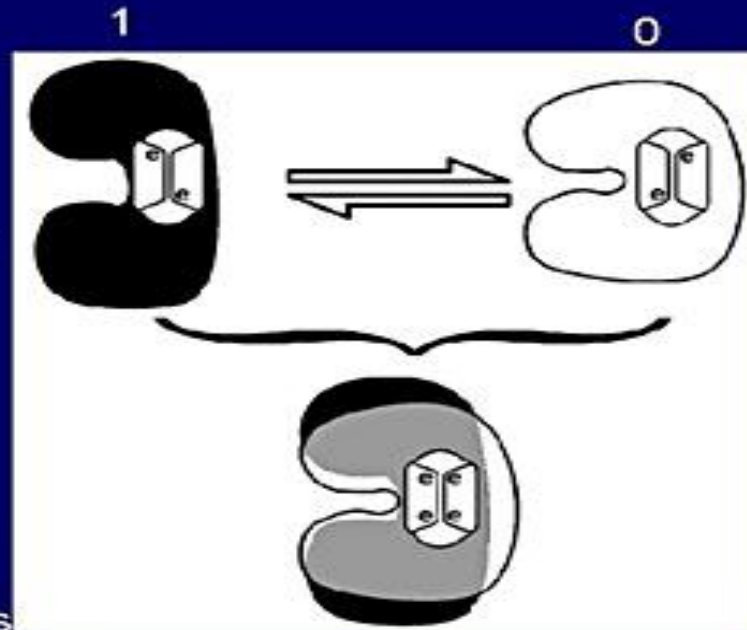
# Tubulins switch in nanoseconds- $10^{-9}$ .

## Intratubulin pockets switch in femtoseconds – $10^{-14}$

Basic idea in Orch OR - each tubulin in a microtubule is a qubit

Protein (tubulin) flips between two states, governed by quantum London forces in hydrophobic pockets

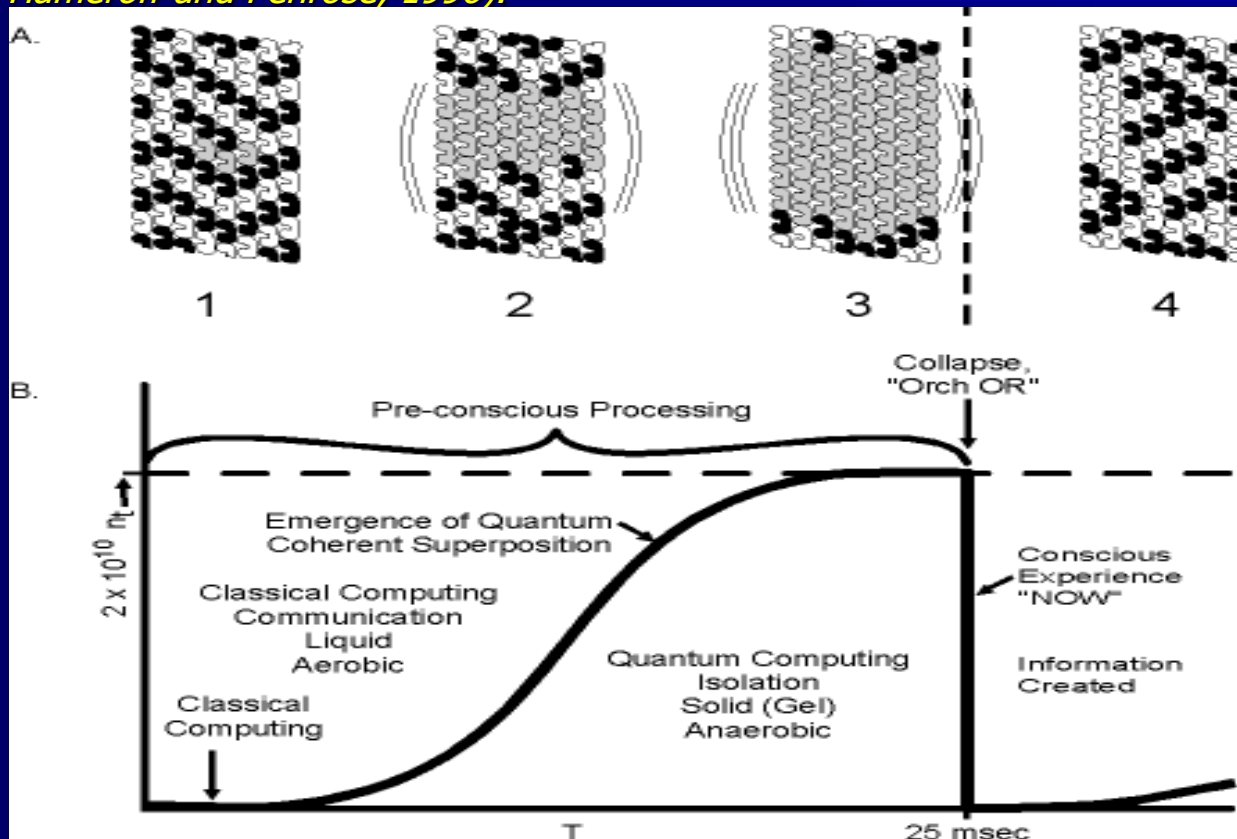
If governed by quantum effects, tubulin may also exist in both states quantum superposition



Switching occurs in nanoseconds  $10^{-9}$  sec

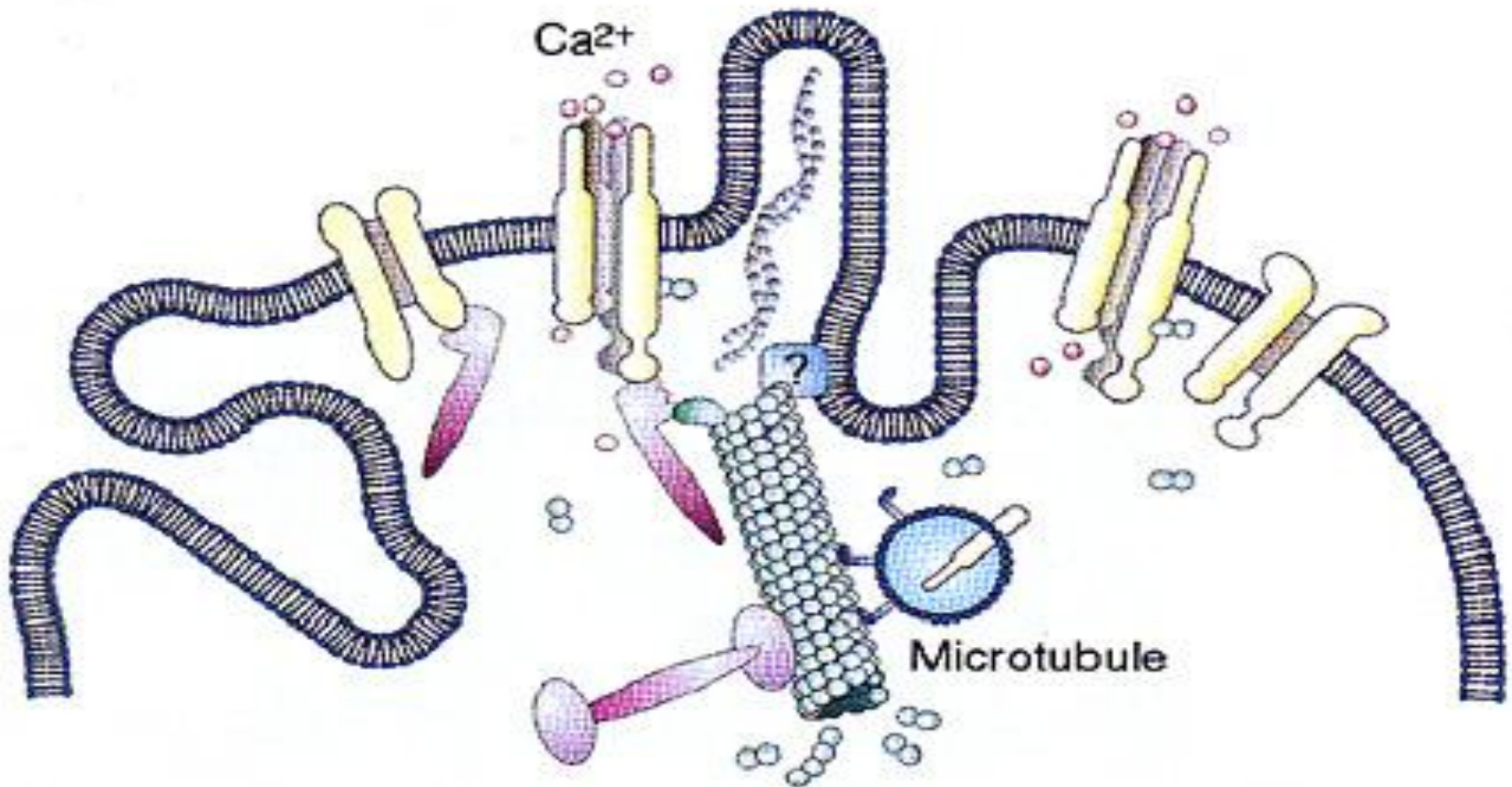
1 AND 0  
Qubit

■ *An Orch OR event. a) Microtubule simulation in which classical computing (step 1) leads to emergence of quantum coherent superposition (and quantum computing (steps 2-3) in certain (gray) tubulins. Step 3 (in coherence with other microtubule tublins) meets critical threshold related to quantum gravity for self-collapse (Orch OR). A conscious event (Orch OR) occurs in the step 3 to 4 transition. Tubulin states in step 4 are non-computably chosen in the collapse, and evolve by classical computing to regulate neural function. b) Schematic graph of proposed quantum coherence (number of tubulins) emerging versus time in microtubules. Area under curve connects superposed mass energy  $E$  with collapse time  $T$  in accordance with  $E = h/T$ .  $E$  may be expressed as  $Nt$ , the number of tubulins whose mass separation (and separation of underlying space time) for time  $T$  will self-collapse. For  $T = 25$  msec (e.g. 40 Hz oscillations),  $Nt = 2 \times 10^{10}$  tubulins. (With permission of Hameroff and Penrose, 1996).*



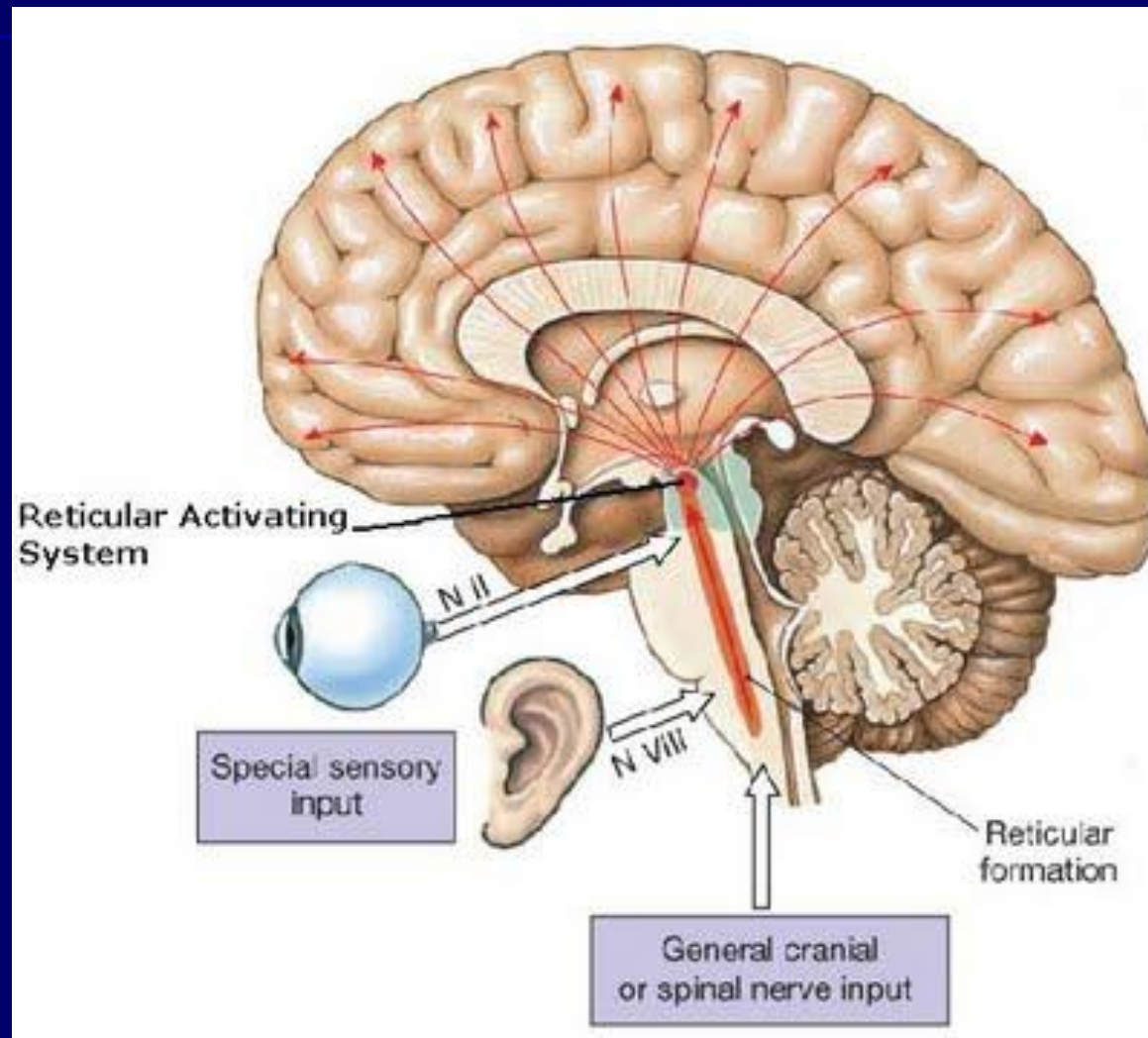


# Microtubular computing automata into dendrite neurocyte interior



# Reticular activating system

## 2. Functions

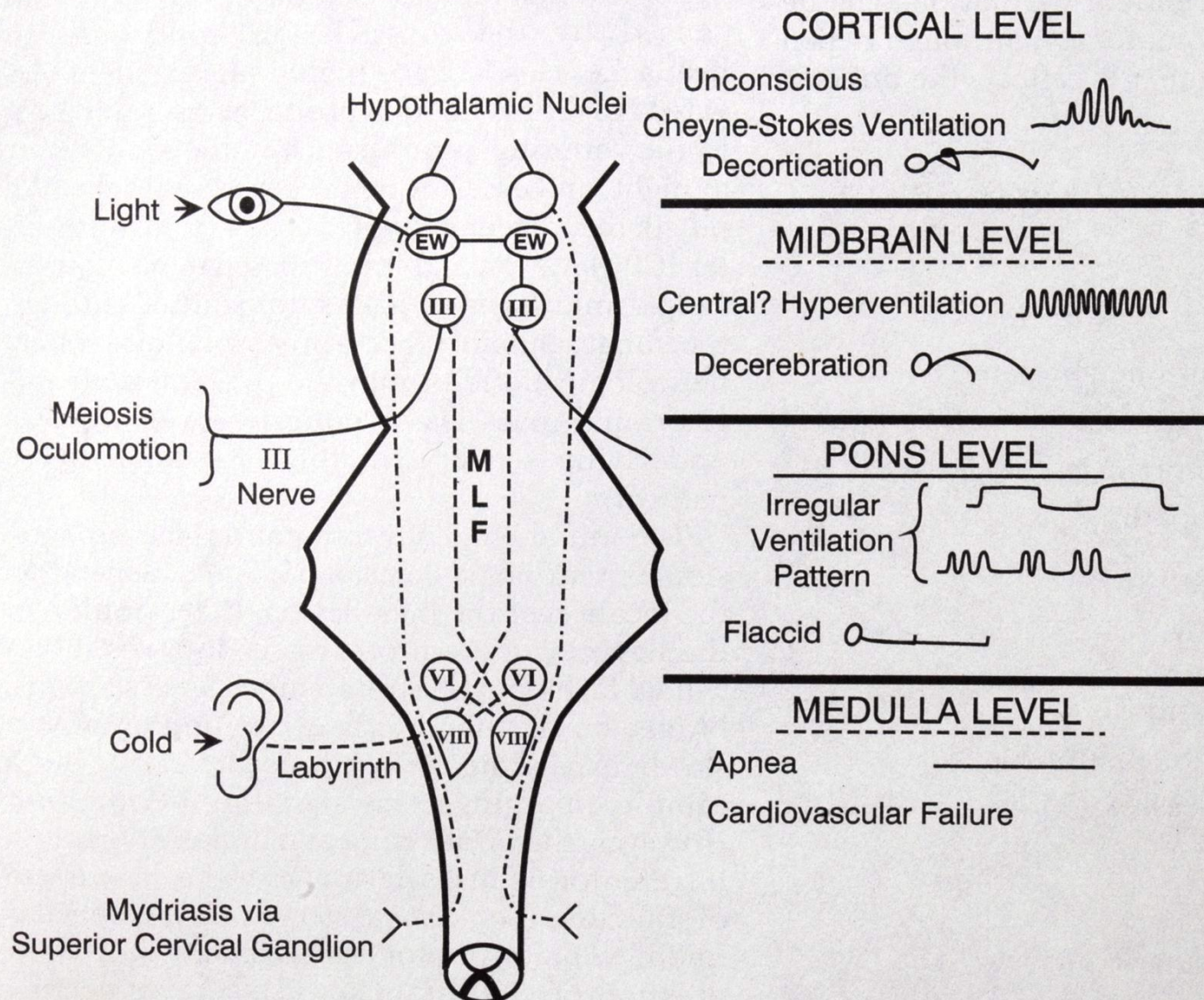




# The reticular activating system (RAS)

- The functions this system influence also human behaviour and affects cognition.
- **RAS** controls the ability to focus and to shift through incoming information.

# RAS and its topic damage



# Reticular Activating System:

## 1. Location and Structure

- ***RAS connects the lower parts of the brain***, which is the brainstem, to the cerebral cortex through various neural paths.
- ***The brainstem controls*** most of the ***involuntary functions as well as reflexes of the body***, while ***cerebral cortex is the seat of consciousness and thinking abilities***.
- The reticular activating system forms a link between these ***two different regions***.
- ***It is a bridge between the upper brain and the lower brain***.

# R A S

- is responsible for providing an integrated (cardiovascular, respiratory and motor) response to external stimuli.
- The ability to filter out information from external sources and focus on one particular fact, detail or thought is controlled by the RAS.
- It also controls **coordination during walking, sexual functions and eating habits.**

# Consciousness

Up-to-date neurobiologic definition

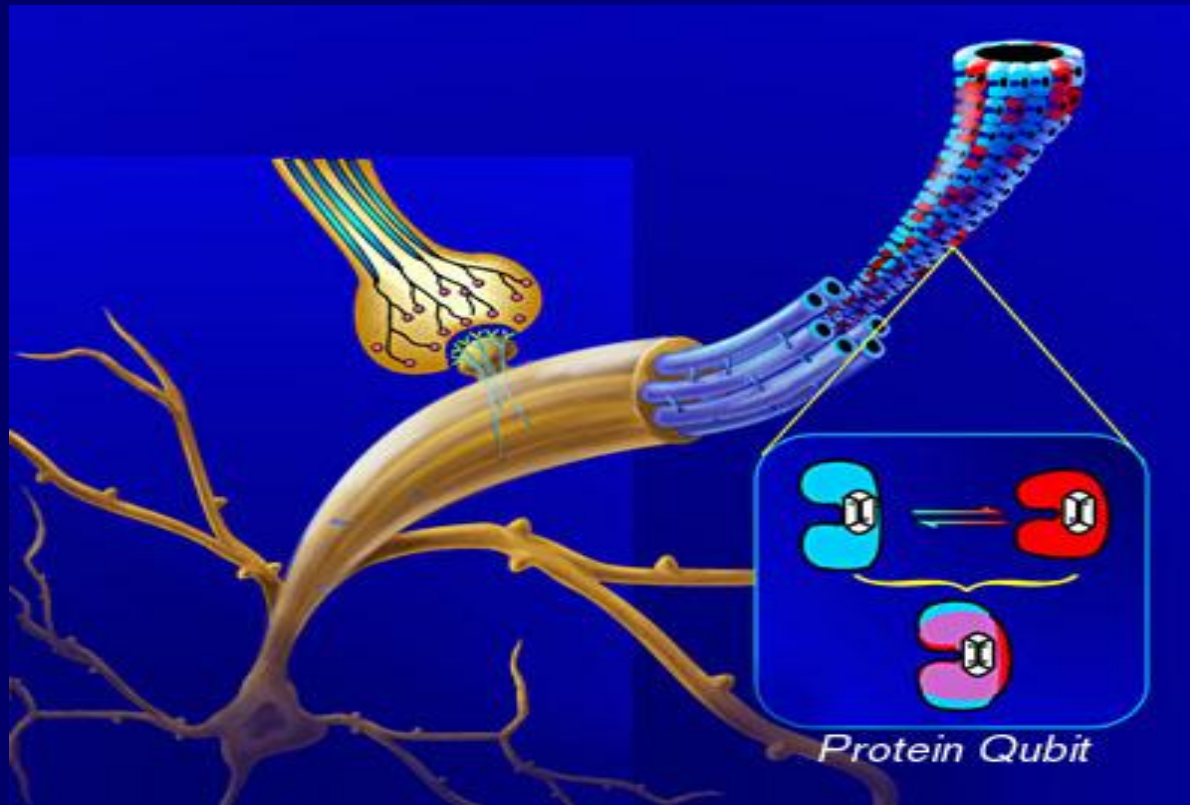
**Axonal spikes convey inputs  
to and outputs from the  
„web“**

(S. Hameroff, Springer, 2007)

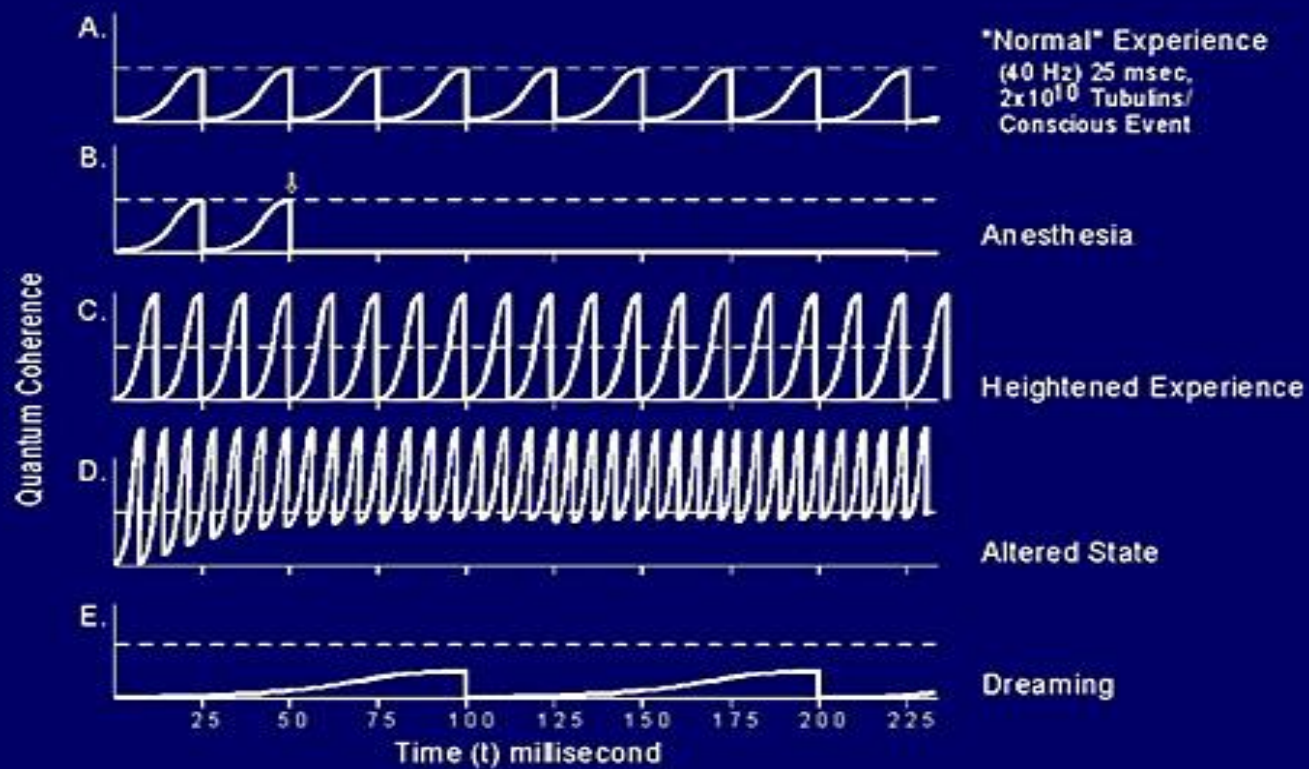


# Tubulin conformational alternation and quantum computation in hydrophobic intratubulin pockets as a key mechanism performing basic consciousness

*(NCC)*



# Conscious experience in E/t relations





# **Holographic processing sensory information**

- **In humans, studies in chemical oscillations and oscillation cellular dynamics strongly indicate that the holographic concept exists not only on the neural level but also on the cellular and molecular levels.**

# Quantum physics principle

**Schempp (1992) has successfully validated the concept of recovery and utilization of non-local quantum information in the case of functional Magnetic Resonance Imaging (fMRI) using quantum holography. Cloned Dolly-sheep is a similar case of the Quantum physics principle**

# Holographic processing sensory information

- **Holographs have a property called “distributedness,” which means that any fractional portion of the recorded hologram contains sufficient information to reconstruct the complete original 3-D information pattern.**

# Neural correlates of consciousness



The NCC is the minimal (minimal, since it is known that the entire brain is sufficient to give rise to consciousness) set of neurons, most likely distributed throughout certain cortical and subcortical areas, whose firing directly correlates with the perception of the subject at the time.

# Neural correlates of consciousness



The specific processes that  
correlate with the current content  
of consciousness are referred to  
as

the neuronal correlate of  
consciousness, or as the  
NCC.

# **Neural correlates of consciousness**



- **Conversely, stimulating these neurons in the right manner with some yet unheard of technology should give rise to the same perception as before, but with delay 500ms.**

# Libet's experiments and explanation of the delayed conscious experience

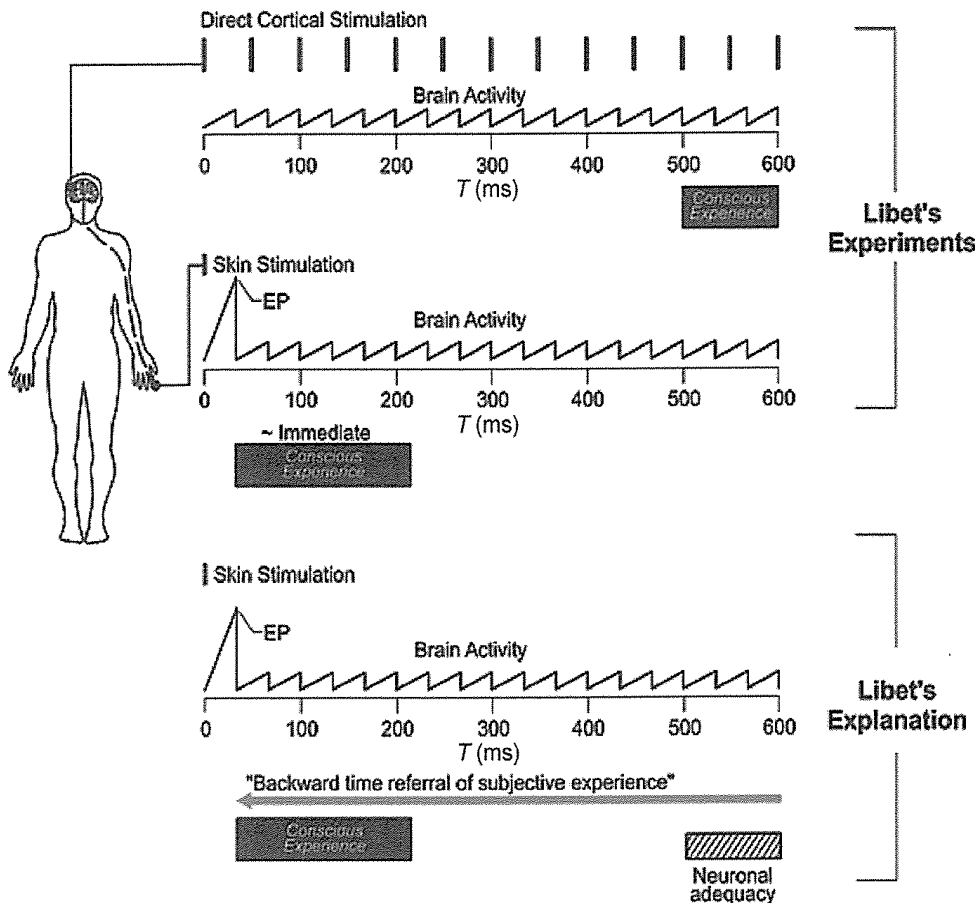


Fig. 6.2. Libet's experiments and explanation [138, 142]. Patient (*left*) was accessed 1) at hand area of somatosensory cortex, and 2) skin of corresponding hand. *Top*: Direct cortical stimulation of electrical pulses every 50 ms caused cortical brain activity that was required to proceed for 500 ms to cause conscious experience of a sensation in the hand. *Middle*: Single pulse to the skin of the hand caused primary evoked potential (EP) after 10 to 30 ms and ongoing brain activity for at least 500 ms. Conscious experience occurred concomitant with primary EP. *Bottom*: Libet's explanation – 500-ms ongoing activity required for neuronal adequacy, which refers subjective experience backward in time to the primary EP



# **Libet's experiments and explanation of the delayed conscious experience**

**Therefore recall must to retrospectively shift our conscious experience by 500ms to the past time to be accepted subjectively – illusory as a near-immediate sensoric event, sensoric experience**

# Consciousness



- **Awareness** implies both that the brain is aroused and that there are specific perceptual qualities of an experience (e.g., the redness of a rose).

The modifier “**explicit**” distinguishes conscious awareness from other cognitive processes in the brain that remain implicit or unconscious.

- It is important to note that “**explicit awareness**” does not necessarily imply “**explicit recall**,” as it often does in the discussion of awareness under anesthesia.



***Thank you for your attention***









# **Holographic processing sensory information**

**Much research exists regarding holographs in nature. These studies show that dolphins, bats, fish, flies, birds, and humans all process sensory information holographically.**

# **Holographic processing sensory information**

**Consequently, it can be posited that within humans that holographic biophysical radiation can be present in blood, sputum, hair, and other small subsets of the human subject due to this holographic property of distributedness.**

# Quantum physics principle

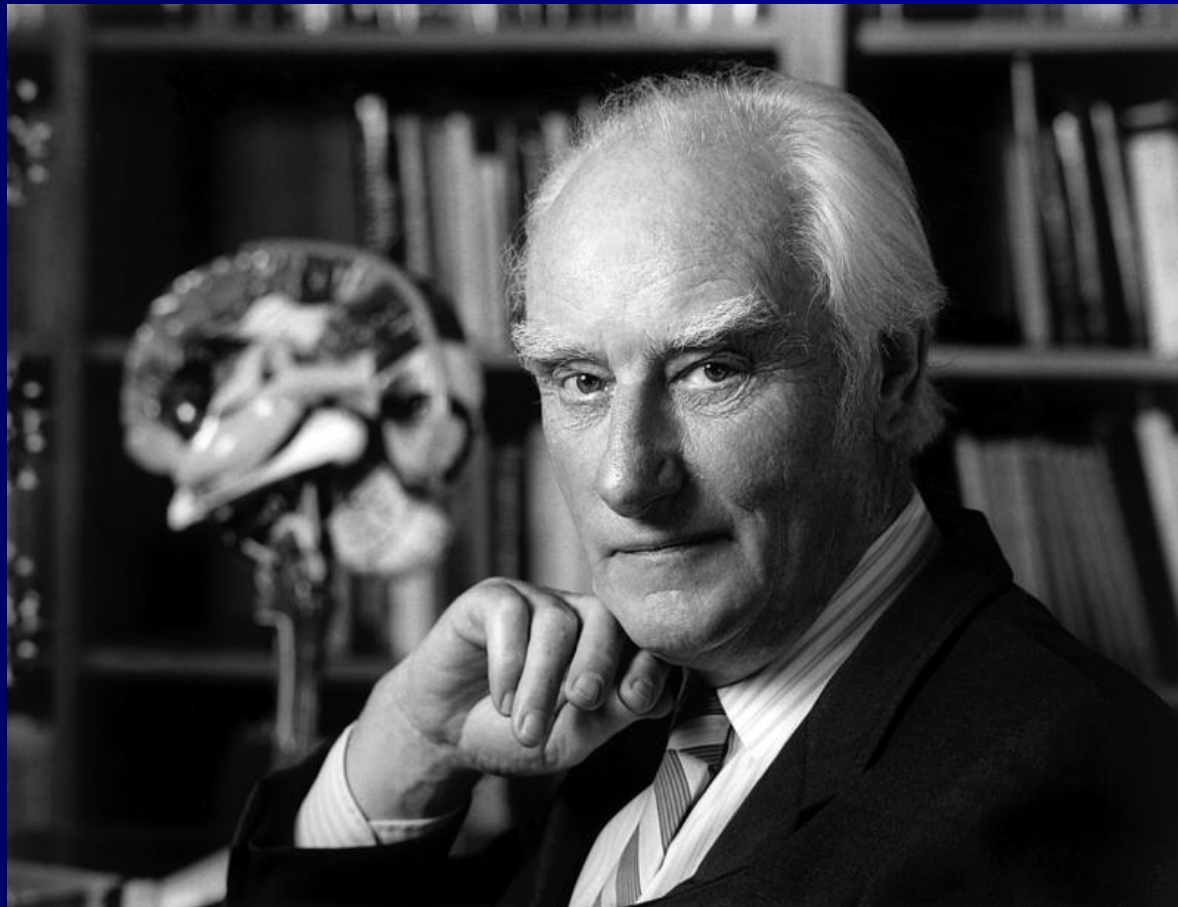
**The percipient, or system sensing the information, and the source of information are in a resonant relationship for the information to be accurately perceived. . . . discovery of the non-local quantum hologram created by the absorption/remission phenomenon and characteristic of all physical objects provides the first quantum physical mechanism compatible with macro-scale three dimensional world as we experience it....**

# Quantum physics principle

**Non-locality and the non-local quantum hologram provide the only testable mechanism discovered to date which offer a possible solution to the host of enigmatic observations and data associated with consciousness and such consciousness phenomena.**

# **Francis Crick (1916 - 2004)**

**The Astonishing Hypothesis. The Scientific Search for the Soul. Simon & Schuster Ltd. London.**



# **Dr. Christof Koch**

## ***Consciousness Researcher***



- **is a professor of computation and neural systems at the California Institute of Technology (Caltech). Koch studies the neuronal basis of consciousness, and especially visual consciousness, since vision is the best understood of all the human senses.**



# Crick and Koch, 1998

- **assume that the function of the neuronal correlate of consciousness is to produce the best current interpretation of the environment in the light of past experiences and to make it available, for a sufficient time, to the parts of the brain which contemplate, plan, and execute voluntary motor outputs (including language transformed in sounds or written words).**

# Consciousness



**Through every moment  
of consciousness experience  
human beings are acquiring  
new information, and relating  
it to past experience.**

# Consciousness

- It is a subject of much research in philosophy of mind, psychology, **neuroscience**, and **cognitive science**.

# Consciousness



**Consciousness** involves four functions:

- stimulus uptake (perception),
- stimulus processing (mnemonic representation),
- stimulus evaluation (emotion), and
- stimulus response (volition).

# Consciousness



- These processes are integrated by complex neuronal systems to achieve regional linking within one modality, temporal, and semantic binding of information.

(Pöppel, and Schwender, 1993).

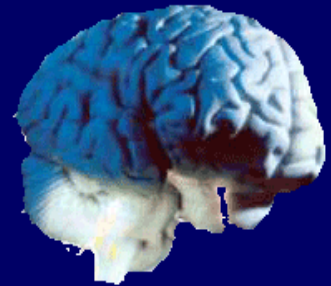
# Consciousness



- It should be clear that the neural correlates of particular conscious modalities (e.g., **the visual**) must ultimately **be combined** with other modalities (e.g., **the auditory**) to generate perception.



# Consciousness



- The major question that neuroscience must ultimately answer can be bluntly stated as follows: *it is probable that at any moment some active neuronal processes in our brain correlate with consciousness, while others do not:*  
***what is the difference between them?***

# Consciousness



- Small lesions in the brain stem and thalamus of patients can lead to a complete loss of consciousness, while destruction of circumscribed parts of the cerebral cortex of patients can eliminate only very specific aspects of consciousness, such as the ability to be aware of motion or to recognize objects as faces, without a concomitant loss of vision in general.

# Consciousness



A neuronal enabling factor for consciousness is

***the intralaminar  
nuclei of the thalamus.***

# Consciousness



- Among the neuronal modulating factors are the various activities in nuclei in the brain stem and the midbrain, often collectively referred to as the ascendent reticular activating system, which control in a widespread and quite specific manner the level of noradrenaline, serotonin, and acetylcholine in the forebrain.

# Consciousness



- Appropriate levels of these neurotransmitters are needed:
  - for sleep, arousal, attention, memory, and
  - other functions critical to behavior and consciousness

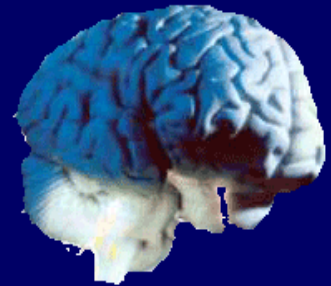
# Consciousness



- Acute bilateral loss of function in these small structures that are widely and reciprocally connected to the basal ganglia and cerebral cortex leads to immediate coma or profound disruption **in arousal and consciousness.**



# Consciousness



Currently, there are three  
basic approaches to the question  
of consciousness:

- the philosophical
- the physical, and
- the neuroscientific

# Neural correlates of consciousness



➤ The neuroscientific approach to the study of consciousness is characterized by the search for the

**“neural correlates of consciousness”**

# **Neural correlates of consciousness (NCC)**

- **The problem of consciousness  
can be broken down into  
several separate questions.  
Most, if not all of these, can  
then be subjected to scientific  
inquiry.**

# **Neural correlates of consciousness**

- **may be identified through a number of methods, including:**
  - ❖ **clinico-pathologic correlation (e.g., in stroke or epilepsy),**
  - ❖ **functional neuroimaging and**
  - ❖ **neurophysiologic recording in association with a cognitive task.**

# **Neural correlates of consciousness**

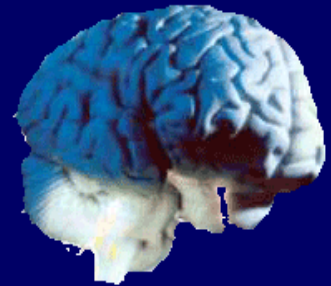
- **Discovering the NCC and its properties will mark a major milestone in any scientific theory of consciousness.**

# **Neural correlates of consciousness (NCC)**

The present article reviews the basic history and principles of the scientific investigation of consciousness, discusses proposed **mechanisms of anaesthesia** that explicitly **consider neural correlates of consciousness (NCC)**, and argues for an integrated approach to the study of **consciousness and anaesthesia.**



# Consciousness



- For the sake of the present arguments, consciousness is defined as **“explicit awareness.”**
- The term **“awareness”** is chosen because of its consistency with the current terminology of **anaesthesiology**, i.e., awareness is typically regarded in **contradistinction to anaesthesia.**

# Awareness



- The term '**awareness**' is explained as "**having knowledge, conscious, cognizant**" (Anonymous, 1989).

The term represents the state of mind at a certain moment of time irrespective of whether that state is later recalled or not (Ghoneim, and Mewaldt, 1990).

# **Awareness**

**In medical terminology, the term  
"awareness"  
has sometimes been regarded as  
meaning only consciousness during  
general anaesthesia (Critchley,1978).**

# **“Awareness during general anaesthesia”**

The term **“awareness during general anaesthesia”** is however almost universally accepted by both medical and legal circles, and its meaning is well understood.

# Awareness during anesthesia

- Canadian Medical Association Journal  
**CMAJ. 2008 January 15; 178(2): 185–188.** doi:  
10.1503/cmaj.071761.PMCID: PMC2175003Copyright  
© 2008 Canadian Medical Association

## Anesthesiology

**Beverley A. Orser, MD PhD**, C. David Mazer, MD, and Andrew J. Baker, MD  
Beverley Orser, David Mazer and Andrew Baker are with the Department of Anesthesia at the University of Toronto, Toronto, Ont. Dr. Orser is also with the Department of Anesthesia at Sunnybrook Health Sciences Centre, Toronto, Ont. David Mazer and Andrew Baker are with the Department of Anesthesia and the Keenan Research Centre, Li Ka Shing Knowledge Institute at St. Michael's Hospital, Toronto, Ont.

# **Awareness during anesthesia**

**The causes of intraoperative awareness are as yet unknown, and the problem may be multifactorial.**

**There are 4 broad categories of causes are plausible:**



# **Awareness during anesthesia**(Cheng and coll.2006)

**found that:**

- *a genetic deficiency in one type of receptor for the inhibitory neurotransmitter  $\gamma$ -aminobutyric acid (receptors that contain the  $\alpha 5$  subunit) conferred resistance to the memory-blocking properties of the anaesthetic etomidate.*

# **Awareness during anesthesia**(Kim et al. 1997)

- **Polymorphisms for the  $\gamma$ -aminobutyric acid A receptor 5 gene (GABA5) exist in the human genome, and there are at least 3 distinct messenger RNA isoforms in human adult and fetal brain tissue.**

# **Awareness during anesthesia** (Ezri et al.2007)

**Human studies have shown that**

- **the immobilizing dose of anesthetic may vary by as much as 24% in populations with different genetic backgrounds.**
- **Thus, pharmacogenetics may be one factor contributing to intraoperative awareness.**

# Awareness during anesthesia

It depends on: how much of dendritic web are excluded from the NCC, e.g. how much tubulin's mass is desactivated due to hydrophobic pockets to stop their alternative conformation in bits of  $\alpha$ -tubulin and  $\beta$ -tubulin and superposition in  $\alpha\beta$ -qubit?

**Occasional assembly of neurons in  
–kilo, -mega or –giga seize=NCC**

**Consciousness is a quantum process not occurring in any one brain region, or in any one type of neuron or particular protein, rather consciousness occur in hydrophobic pockets of a class of proteins in dendrites throughout the brain Hameroff, 1997).**

# General anaesthesia



As general anaesthesia is defined as **a state of unconsciousness**, it would logically follow that a patient under general anaesthesia cannot be aware, and the converse.

**If the brain is anaesthetized, consciousness ceases.**



# General anaesthesia



➤ **General anesthesia is a state characterized by unconsciousness, analgesia, muscle relaxation, and depression of reflexes (Willenkin, 1990) or, the administration of chemical agents to produce reversible unconsciousness and depression of reflex response to afferent stimuli (Critchley, 1978).**

# General anaesthesia

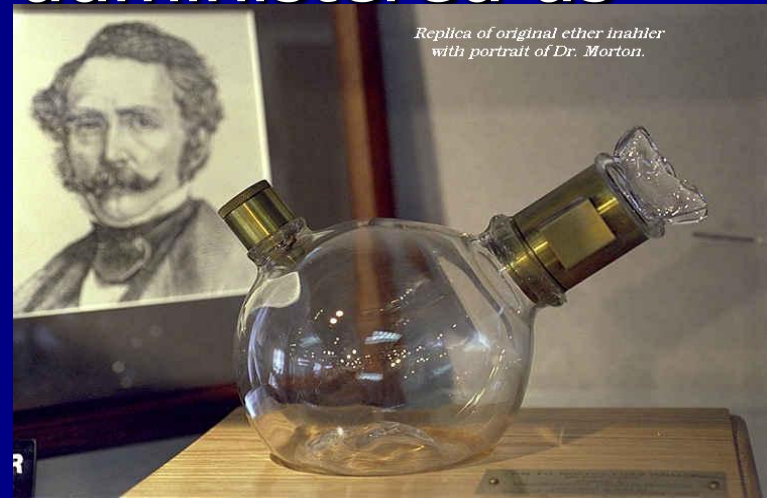


**In modern medical practice,  
general anaesthesia is a state  
of total unconsciousness resulting  
from  
general anaesthetic drugs**

# A Brief History of General Anaesthesia

- Anaesthesia was first demonstrated successfully in 1846 at the Massachusetts General Hospital and over the next decade **chloroform, ether and nitrous oxide** were administered as general anesthetics.

➤ Ether



# The anaesthetic drugs

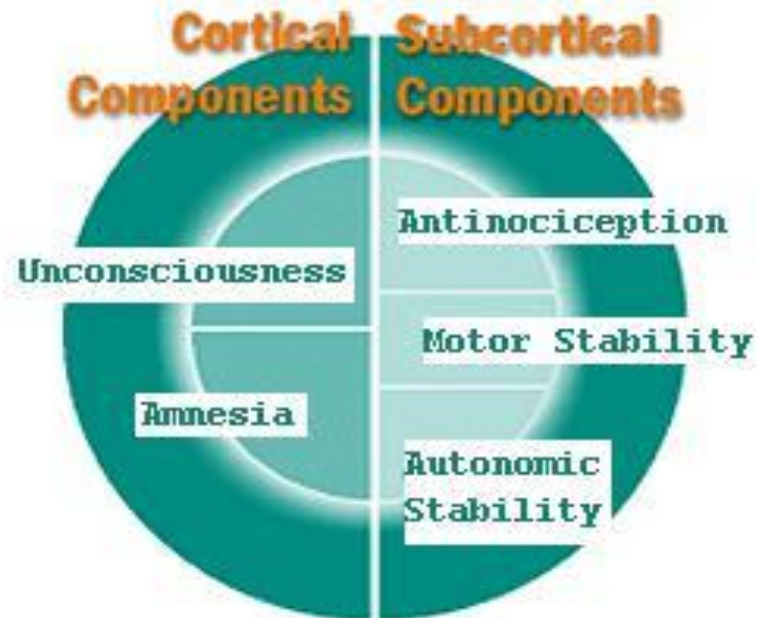
- are the drugs that bring a reversible **loss of consciousness**
- these drugs are generally administered by an anaesthesia provider in order to induce or maintain general anaesthesia to facilitate surgery

# General anaesthetics

**are drugs that:**

- depress the function of cerebral cortex
- decrease the awareness of the patient as the dose of the drug increases versus unconsciousness on memory consolidation
- **but also to study** the affect of various levels of consciousness on memory.

# General anaesthesia





# General anaesthesia



- The clinical use of these diverse agents also led to a fundamental scientific question:

**what is the mechanism  
of general anaesthesia?**

# Mechanism anaesthetics

- As early as 1847, von Bibra and Harless suggested that anaesthetics dissolve and remove lipids in the brain.
- In 1875, Claude Bernard formulated the original “unitary hypothesis” of general anaesthesia, suggesting that all of these structurally and pharmacologically diverse agents have a final common mechanism.

# Mechanism anaesthetics

- Around the turn of the 20th century, Meyer and Overton, observed that the potency of volatile anaesthetics was correlated with their **solubility in olive oil**.
- The synthesis of these ideas led to the “**lipid hypothesis**” of general anaesthesia, the proposition that anaesthetics act by nonspecific perturbation of **lipid cell membranes in neural tissues**.

# Mechanism anaesthetics

- Variations on the lipid membrane hypothesis of general anaesthesia persisted late into the 20th century until Franks and Lieb demonstrated in 1984 that anaesthetics inhibit lipid-free preparations of the enzyme firefly luciferase in parallel with their hydrophobicity.

# Mechanism anaesthetics

- Since the time of this discovery, **the specific actions of anaesthetics on protein substrates have been investigated.**
- Despite the potentially “promiscuous binding” of anaesthetics, **the primary focus of molecular targets has been ion channels.**

# **Mechanism anaesthetics**

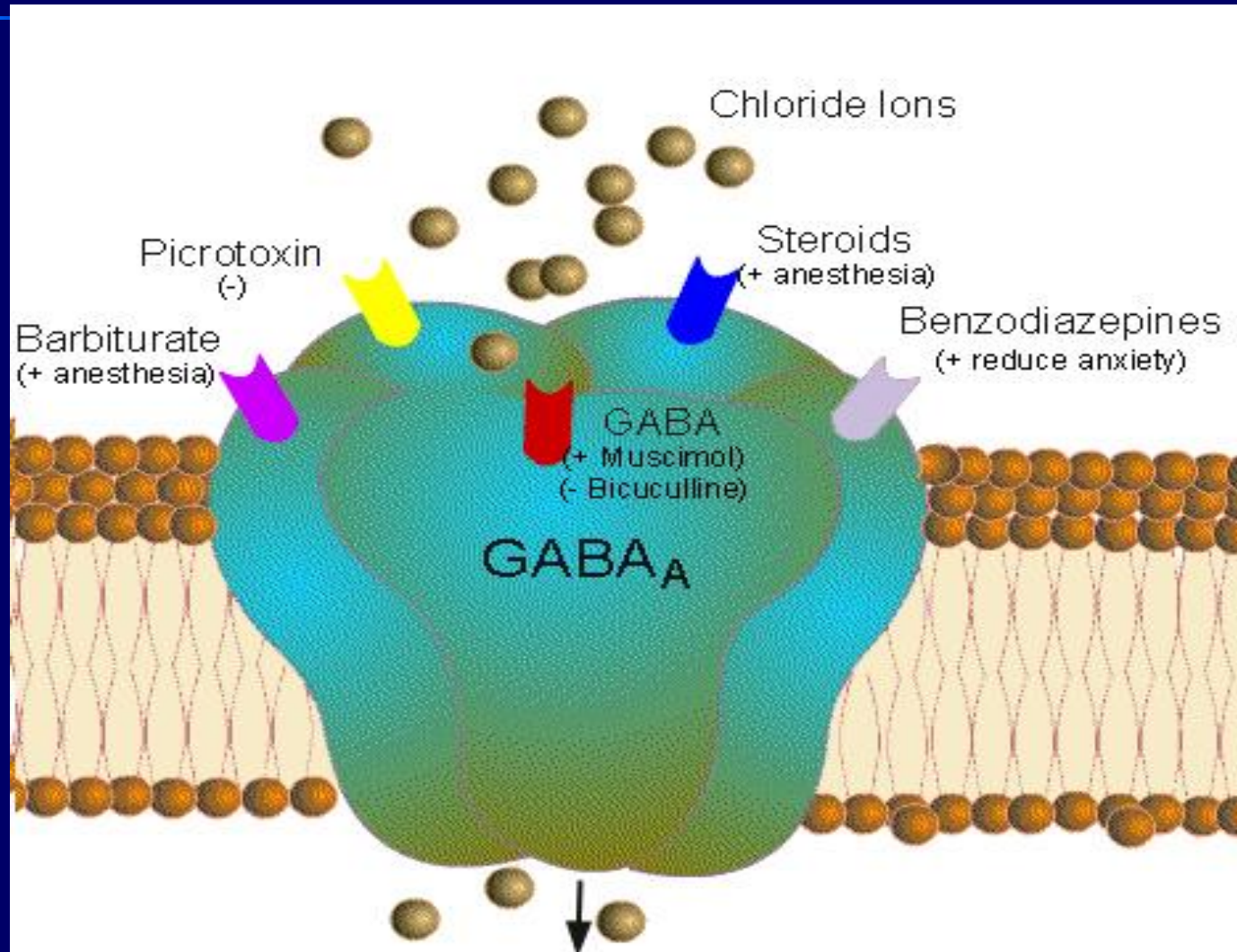
- **Ion channels serve a number of functions within the neuron and are the molecular mediators of the neurophysiology that forms the basis of consciousness.**

# Mechanism anaesthetics

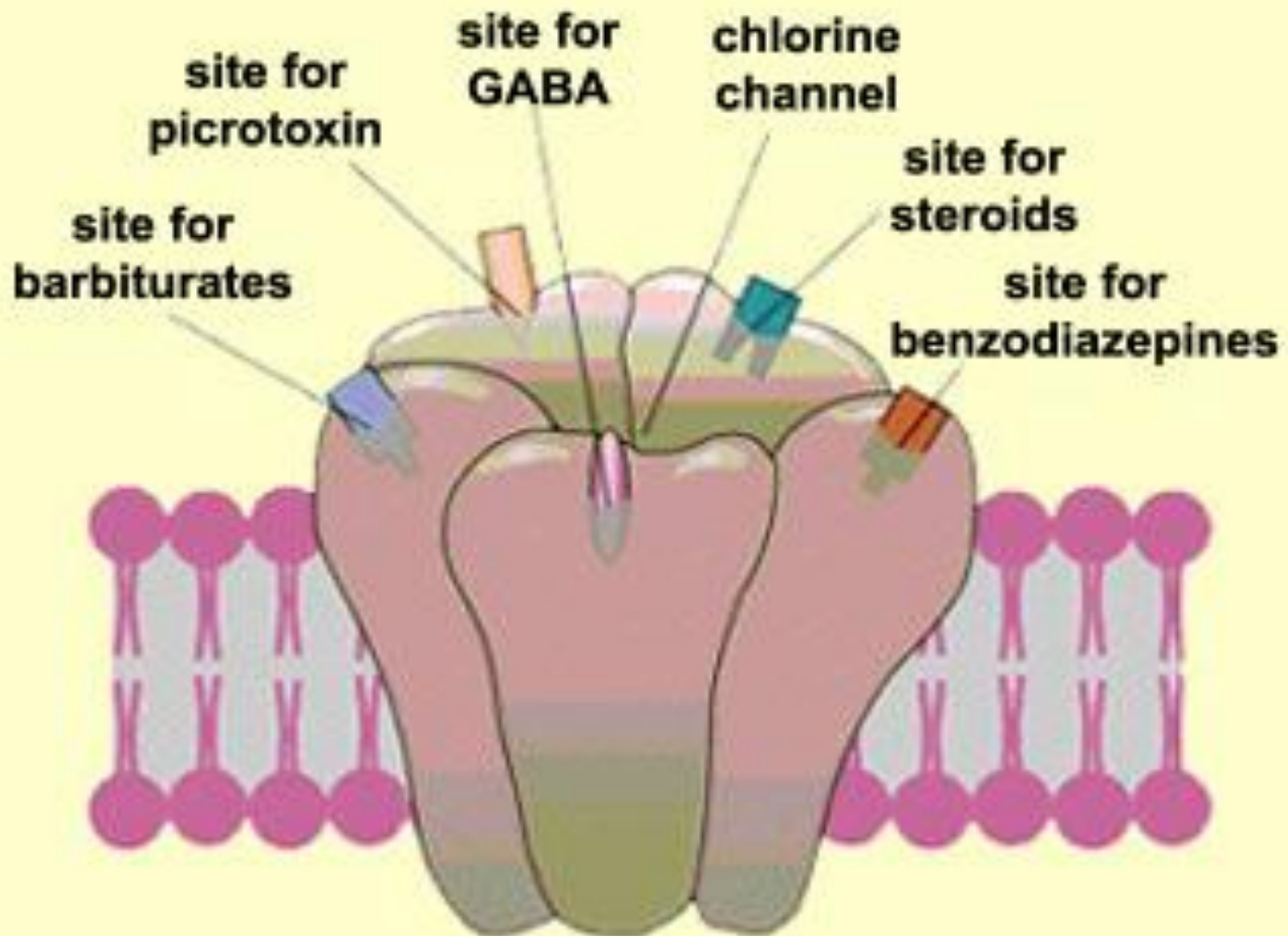
General anaesthetics affect a number of different neurotransmitter receptors, including gamma-aminobutyric acid (GABA) type A, nicotinic acetylcholine, and glutamate receptors in the brain, as well as glycine receptors in the spinal cord.



# General anaesthetics affect a number of different neurotransmitter receptors



# General anaesthetics affect a number of different neurotransmitter receptors



# Mechanism anaesthetics

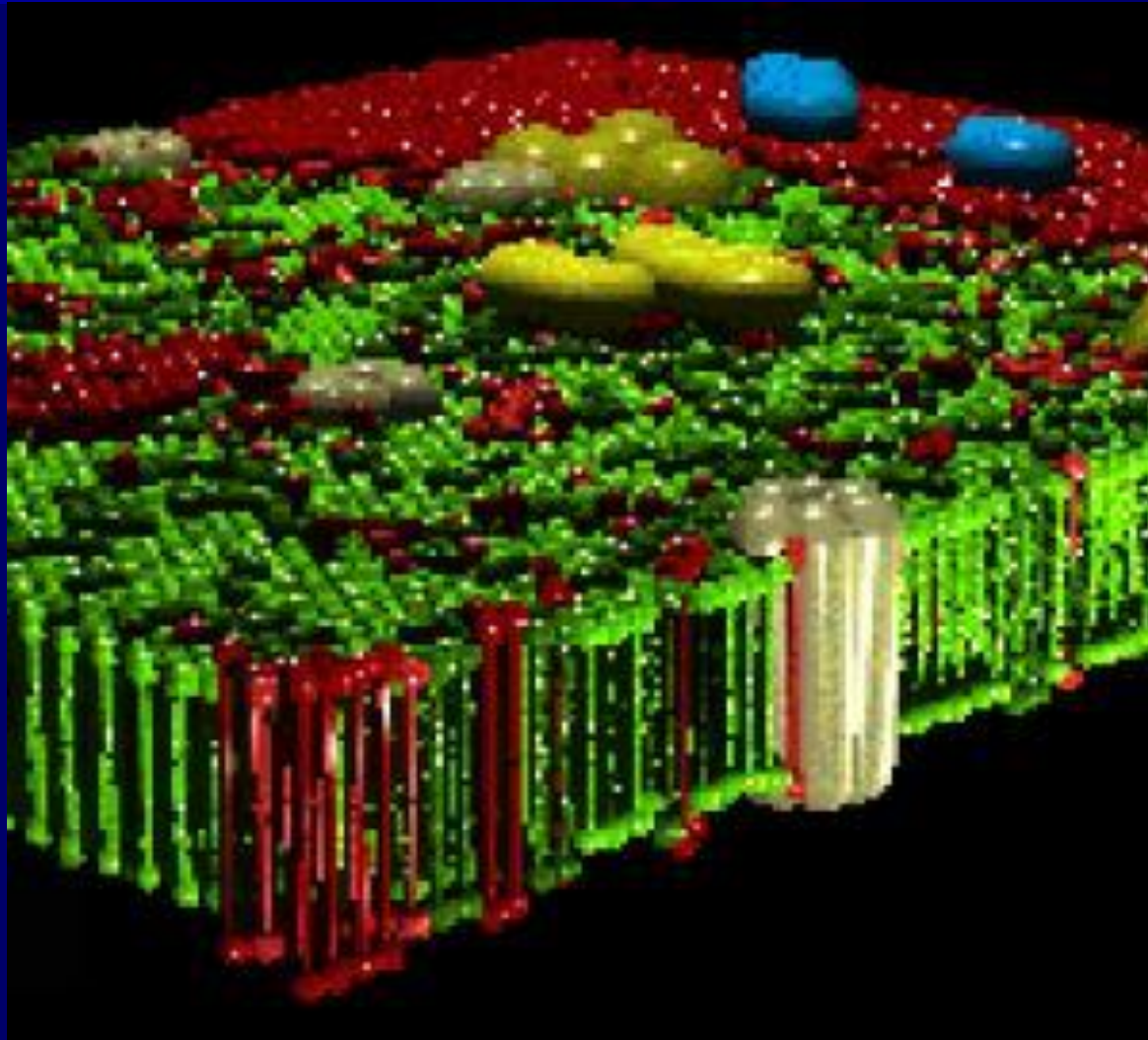
- The **central cholinergic system** plays a major role in regulation of cognitive functions: inhibition of central nicotinic and muscarinic cholinergic receptors (nAChRs and mAChRs) **contributes to learning and memory impairment, and delirium .**

# Mechanism anaesthetics

- Drugs used as part of general anaesthesia **interact with central cholinergic receptors and may modulate cognitive functions.**
- **Volatile anaesthetics are potent inhibitors of nAChRs.**
- Propofol (intravenous anaesthetic) exerts an inhibitory effect on nAChRs, but only at concentrations higher than those necessary for anaesthesia.



***The figure shows a biological membrane. The green molecules are liquid, and the red are solid. Molecules of anaesthetics reduce the number of red areas so that the sound pulse can no longer transport its signal. The nerve is anesthetised. (Credit: Illustration by Heiko Seeger, PhD., 2007)***



# **Neuroanatomical structures**

**Neuroanatomical structures affected by general anaesthetics include:**

- ❖ **thalamus, cuneus, and precuneus,**
- ❖ **posterior cingulate cortex, orbitofrontal cortex, and right angular gyrus.**
- ❖ **The molecular, neuronal, and neurophysiologic effects of general anaesthetics have been extensively reviewed elsewhere**

# **Current Theories of General Anaesthesia**

**John ER., Prichep LS.:**

**The anaesthetic cascade:  
a theory of how anaesthesia  
suppresses consciousness.**

**Anesthesiology 2005,102,p.447-71.**



# **The proposed “cascade” is as follows:**

- 1. **Depression of the brainstem** reduces the influences of the ascending reticular activating system on the thalamus and cortex.
- 2. **Depression of the mesolimbic-dorsolateral prefrontal cortex** interactions leads to blockade of memory storage.
- 3. Further **depression of the ascending reticular activating system** leads to hyperpolarization of GABAergic neurons in the nucleus reticularis of the thalamus, resulting in

# **The proposed “cascade” is as follows:**

- **4. Blockade of thalamocortical reverberations** and the associated gamma-oscillations underlying perception, as well as
- **5. Functional uncoupling of parietal-frontal cortical activity**, interrupting cognition, and finally
- **6. Reduced awareness** and increase of frontal  $\delta$  and  $\theta$  band activity.

# Current Theories of General Anaesthesia

- The cascade is organized by first describing molecular actions of anaesthetics then linking these actions to neural correlates of consciousness such as thalamocortical resonance and gamma oscillations ( >40 Hz).

# **Current Theories of General Anaesthesia-2005**

- The previously discussed frameworks of consciousness and anaesthesia are not dependent on depressive actions of anaesthetics but instead focus on the disorganization of processes that bind information together (associating areas).



# Our Research

- Learning during general anaesthesia, in the absence of explicit recall for intra-operative events, is being increasingly recognized as a reproducible phenomenon.



# **Learning and general anaesthesia**

- **Therefore our study focused on undesirable side effects of general anaesthesia in some CNS functions among them memory and learning.**

# Learning and general anaesthesia

❖ This study have examined postoperative **implicit and explicit recall** of sounds, words, phrases, specific and general suggestions presented intraoperatively to apparently adequately anaesthetized patients.



# **Learning and general anaesthesia**

- A persisting question is whether implicit memory merely involves the activation of pre-existing knowledge, or can support new learning as well.
- There is evidence that sounds are registered in some areas of the cerebral cortex during general anaesthesia.



# **Our research**

- **The research was approved by Scientific Board of Jessenius Faculty of Medicine in Martin, Comenius University in Bratislava, Slovak Republic.**

**Each of the patients were examined by psychologist two or three days before and after surgical procedures.**

**The examination covered the psychological tests:**

- **general interview**
- **visual analogue scale for pain**
- **test for mnesic ability:** declarative memory (Wechsler memory test) Digit span for auditive memory and attention, subtest for semantic declarative memory, Baumler test for learning and memory, Benton Visual Retention Test and last but not least Global mnesic quotient.
- **preoperative anxiety and fear**

# **Learning and general anaesthesia**

**We observed:**

**a total group of 44 patients  
(23 female, 21 male, ASA I or II,  
mean age 37.2 yrs, range 28-49)  
scheduled for gynecologic or  
urologic surgical procedures and  
they have been studied.**

# Learning and general anaesthesia

- We wanted to know:
  - memory of the patients to the pain-related words versus
  - memory of the patients to the non-pain-related words.



# Our research

- **The pain - related words** during general anaesthesia: operation, doctor, knife, bite, blood, crying, needle, pain, fear, death.
- **The non - pain related words** during general anaesthesia: watch, water, dream, lamp, memory, letter, tree, family, bread, hand.



# Results I.

- We found, in the group of patients ones exposed (n=21) two patients with strong memory engram for explicit recall, these patients wrote 2-3 words during follow-up after operation.
- In the group of patients 5-times exposed to words (n=23) there were five patients with higher degree of explicit memory engram. These patients wrote also words exactly recalled from the time of general anaesthesia.





## Results II.

In the group of patients with the non pain related words we found:

- at the ones tape-record application (n=15) only one patient recalled the pain related words, but they were not heard during surgical procedure.



## Results III.

- in the group of patients with five-times exposed tape record (n=29) we found two patients, who performed no exact recall (implicit) for pain, when it was given record of the non-pain-related words (the first patient) and second patient recalled the word, without being aware conditions during perception.



## Results IV.

- At testing of the number applied words, and the words which the patients recalled.
- We have found the significantly higher number of the pain-related words recalled in spite of the lower-number of applied words and the patients who recalled these words.



# Our conclusion I.

We observed **44 patients** operated in the general inhalation anaesthesia.

The effects of the anaesthesia on learning and memory are as follows:

- at testing the number of recalled **pain-related words** versus number of recalled **non pain related words**, it was shown that **the efficacy of learning was higher in the former ( $p < 0.001$ )**.



## Our conclusion II.

- at comparing the number of patients who were exposed to the pain--related words versus the number of patients with the non pain- related words, we found, **that the efficacy of the learning was present more frequent in the former than in the latter**
- **( $p < 0.05$ ).**

# CONCLUSION



**In 1947, Harvard  
anaesthesiologist Henry  
Knowles Beecher published a  
prescient article in *Science*  
entitled**

**“Anesthesia’s Second Power:  
Probing the Mind”.**

# CONCLUSION



**Nearly 60 years later, perhaps the time has come to actualize this “second power.”**

**The scientific pursuit of consciousness and general anaesthesia appear to have converged, suggesting the potential for an integrated science.**



# CONCLUSION



- **The first power (influence of general anaesthesia to mind) in clinical anaesthesia led to a revolution in the 19th century and continues to provide benefits to patients worldwide. Perhaps**
- **second power of anaesthesia can contribute to yet another revolution, providing critical insights to the science of consciousness in the 21<sup>st</sup> century.**

# What is the obvious cause of unconsciousness?

- Loss of consciousness may occur as the result of traumatic brain injury, brain hypoxia (e.g., due to a brain infarction or cardiac arrest), severe poisoning with drugs that depress the activity of the central nervous system (e.g., alcohol and other hypnotic or sedative drugs), severe fatigue, and other causes.

# Consciousness



- The search for **neural correlates of consciousness** (or NCCs) is arguably the cornerstone in the recent resurgence of the science of consciousness.
- The search poses many difficult empirical problems, but it seems to be tractable in principle, and some ingenious studies in recent years have led to considerable progress.

# Historic remarks of anaesthesia

- On October 16, 1846, another dentist, William Thomas Green Morton, invited to the Massachusetts General Hospital, performed the first public demonstration of diethyl ether (then called sulfuric ether) as an anesthetic agent, for a patient (Edward Gilbert Abbott) undergoing an excision of a vascular tumor from his neck. In a letter to Morton shortly thereafter, Oliver Wendell Holmes, Sr. proposed naming the procedure *anæsthesia*.

## Historic remarks of anaesthesia

- Discovered in 1831, the use of chloroform in anesthesia is usually linked to James Young Simpson, who, in a wide-ranging study of organic compounds, found chloroform's efficacy on 4 November 1847. Its use spread quickly and gained royal approval in 1853 when John Snow gave it to Queen Victoria during the birth of Prince Leopold.

## **Dr Horace Wells: the discoverer of general anaesthesia**

**The discovery of anaesthesia  
in the second quarter of the  
19th century was one of the  
greatest advances in  
the history of medicine.**

# General anaesthesia

- ❖ When general anaesthesia was first introduced in medical practice, ether and chloroform were inhaled with the physician manually covering the patient's mouth.
- ❖ Since then, general anaesthesia has become much more sophisticated.



# General anaesthesia

Drugs used as part of general anaesthesia interact with central cholinergic receptors and may modulate cognitive functions. Volatile anaesthetics are potent inhibitors of nAChRs(3). **Propofol, an intravenous** anaesthetic, also exerts an inhibitory effect on nAChRs, but only at concentrations higher than those necessary for anaesthesia (2).

# General anaesthesia

- Loss of consciousness may occur as the result of traumatic brain injury, brain hypoxia (e.g., due to a brain infarction or cardiac arrest), severe poisoning with drugs that depress the activity of the central nervous system (e.g., alcohol and other hypnotic or sedative drugs – **general anaesthesia**), severe fatigue, and other causes.

# General anaesthesia

- Drugs given to induce or maintain general anaesthesia are either given as:
- **Gases or vapors** (inhalational anaesthetics)
- **Injections** – intravenous anaesthetic drugs

# Inhalational anaesthetic substances

- are either volatile liquids or gases
- Many compounds have been used for inhalation anaesthesia, but only a few are still in widespread use.
- Desflurane, isoflurane and sevoflurane are the most widely used volatile anaesthetic today.
- They are often combined with nitrous oxide.

# **A revolutionary depth of anaesthesia monitor.**

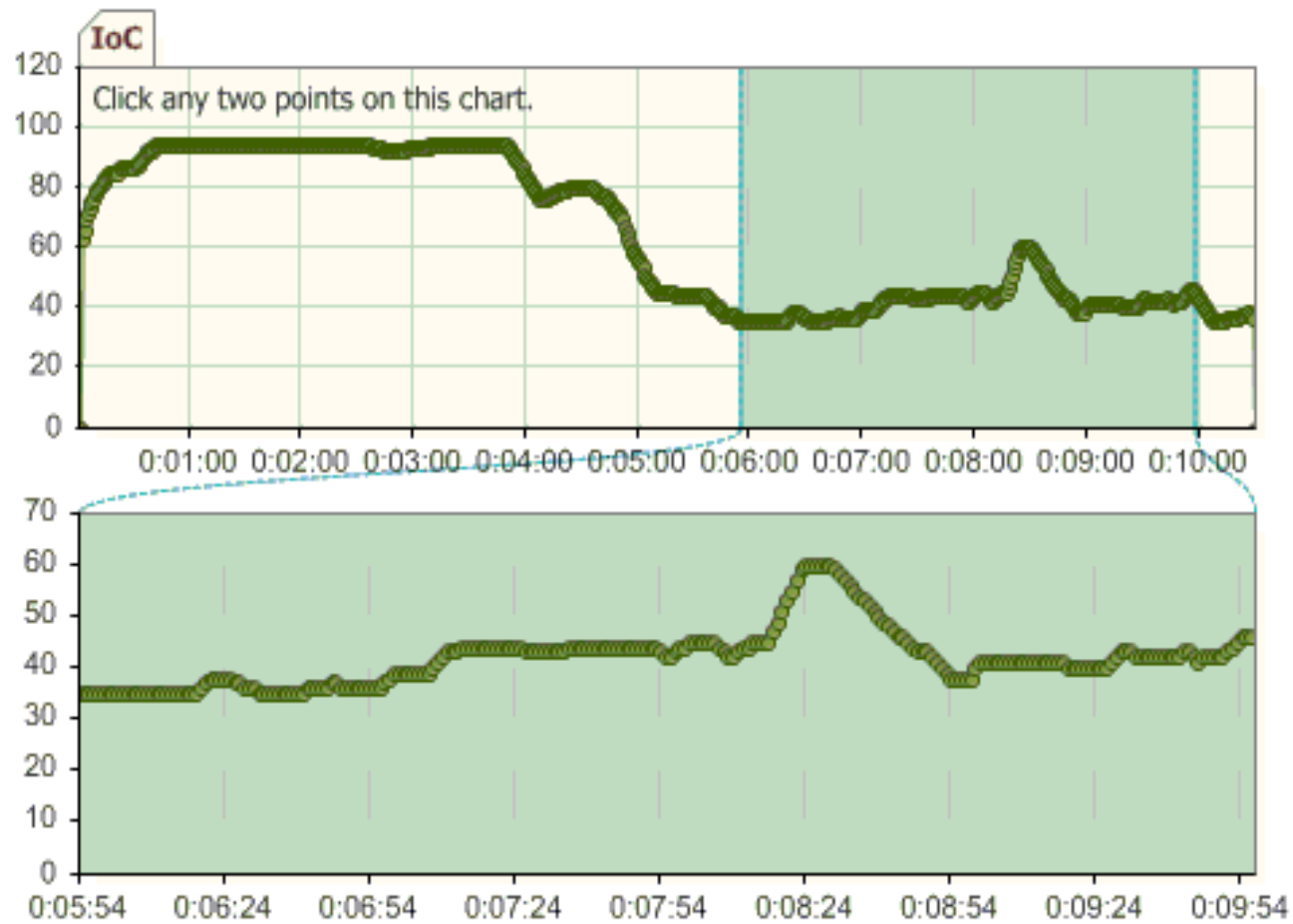
- **The Index of Consciousness, IoC-View, is designed to measure the level of consciousness during general anaesthesia where the correct balancing of anaesthetics or fast recovery is a concern. The IoC-View records the electroencephalogram (EEG) with 3 surface electrodes attached to the forehead of the patient.**

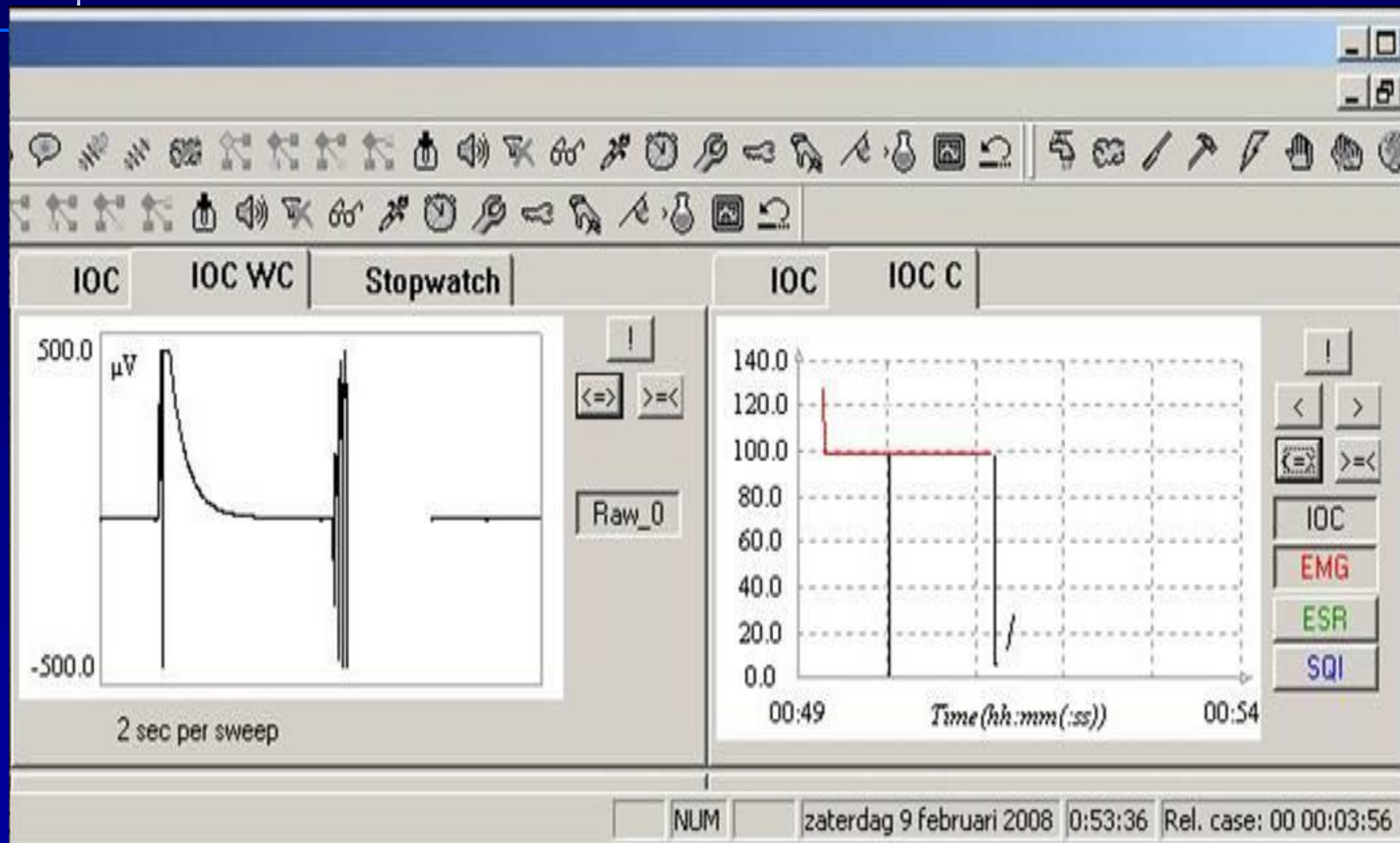












# Consciousness

- The abstract noun “consciousness” is not frequently used by itself in the contemporary literature, but is originally derived from the Latin **con** (with) and **scire** (to know).
- Perhaps the most commonly used contemporary notion of a conscious mental state is captured by Thomas Nagel’s famous “what it is like” sense (Nagel 1974).

# Consciousness



- The 19th century concluded with the belief that consciousness was a legitimate scientific pursuit .
- In the early 20th century, however, consciousness lost legitimacy as a topic of serious inquiry in the two dominant paradigms of psychology.

# Consciousness



- A definition closely following that of James (1894) is as follows:  
**normal consciousness consists of a serially time-ordered, organized, restricted and reflective awareness of self and the environment.**

# Modular perceptual processing

- *The mechanisms by which modular perceptual processing in the brain is synthesized into a single experience appear to be interrupted by the actions of general anaesthetics.*

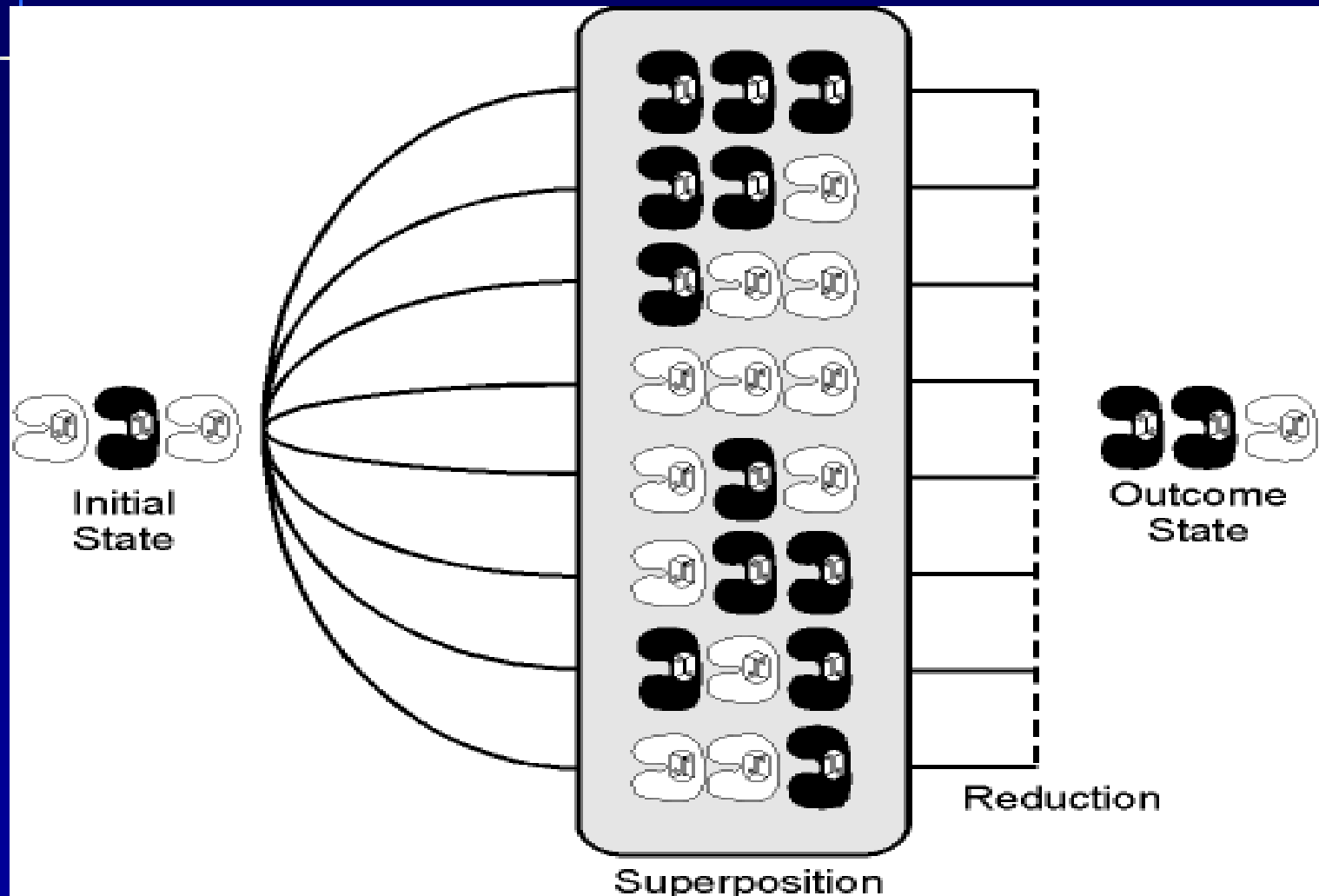


# Unconsciousness



- more appropriately referred to as loss of consciousness or lack of consciousness, is **a dramatic alteration of mental state** that involves complete or near-complete lack of responsiveness to people and other environmental stimuli.

- Schematic of quantum computation of three tubulins which begins (left) in initial classic states, then enter isolated quantum superposition in which all possible states coexist. After reduction, one particular classic outcome state is chosen (right) . *(With permission of Hameroff and Penrose, 1996).*



# **Fate of consciousness as a subject of serious inquiry in 20<sup>th</sup> and 21<sup>th</sup> centuries**

**Disregarded as a subject of serious inquiry throughout most of the 20<sup>th</sup> century, it has now regained legitimacy as a scientific endeavor in 21<sup>th</sup> century.**

