

# **Brief History of Work in the area of Learning and Memory**

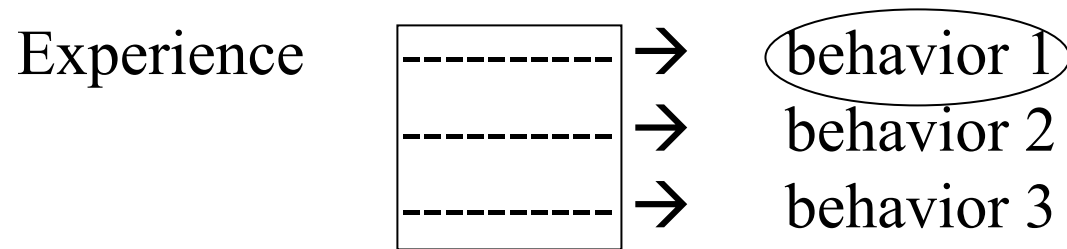
- Basic Questions
- how does memory work
- are there different kinds of memory
- what is their logic
- where in the brain do we learn
- where do we store what is learned as memory
- can memory storage be resolved at the level of individual nerve cells

# What is Learning and what is Memory?

## A Definition

- Learning is an adaptive change in behavior resulting from experience.

From this, the early behaviorists black-box view can be seen as

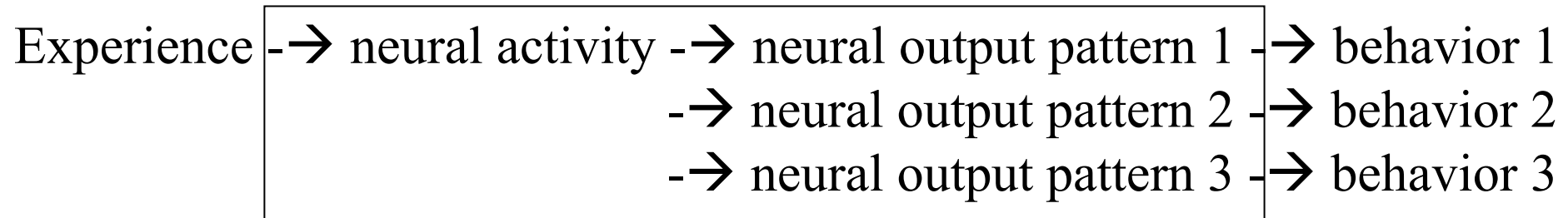


INPUT                  BLACKBOX      OUTPUT

in which selection is based on consequence (e.g. reinforcement, Skinner).

- In non-associative learning, the adaptive advantage is already established.
- In more associative learning the extent of adaptive advantage must be evaluated.

Further refinement of this model in a reductionist direction can be described as



INPUT

BLACKBOX

OUTPUT

In which selection of neural patterns is based on consequence (e.g. reinforcement, Hebb)

# But what does filling in the black box buy us?

- In 1968 Marvin Minsky and Seymour Papert published the book *Perceptrons* challenging the notion that simple linear classifiers ( $A \rightarrow C$ ,  $A + B \rightarrow C$ ) were sufficient to solve general pattern recognition problems.
- Simple linear classifiers are incapable of solving even the simplest linearly inseparable problem such as XOR.
- ``No machine can learn to recognize  $X$  unless it possesses, at least potentially, some scheme for *representing*  $X$ ." (from Minsky & Papert, 1988 edition of *Perceptrons*, MIT Press).

# Representations are the key.

- Representation is a **directed** transformation of inputs designed to **enable** or **facilitate** a specific computation.
- Representations capture useful regularities and structure in the inputs.
- To understand the nature of neural computation, brain function, and the processes of learning and memory, we **must** understand the nature of **internal representations of the world**.

# Let us examine a simple definition of memory

## A Definition

- Memory is [a process related to] the retention of learning.
- A function of memory is to allow production of learned/adaptive behavior at a later time.
- But the adaptive response may not be the same as the original learned behavior (when does learning occur?).
- Note that our simple description of the learning process involved the selection of behavior based on the evaluation of consequence.
- Memory also involves a process by which past experience can be used to guide future (novel) adaptive behavior.

# What is the brain trying to do?

- The brain builds models of the world that can be used to guide adaptive behavior.
- These models will depend upon establishing representations of things in the world based upon identification of statistical regularities.
- These regularities are things that tend to be related to one another and so can be used as the basis for prediction.
- Learning involves extracting these regularities from experience.



# Factors that influence learning

- Repetition -> predictability
- Magnitude -> salience
- Order/timing -> causality
- Reinforcement -> significance/valence

How does this fit into the idea of model building?

Can these factors be related to mechanisms at a cellular level?

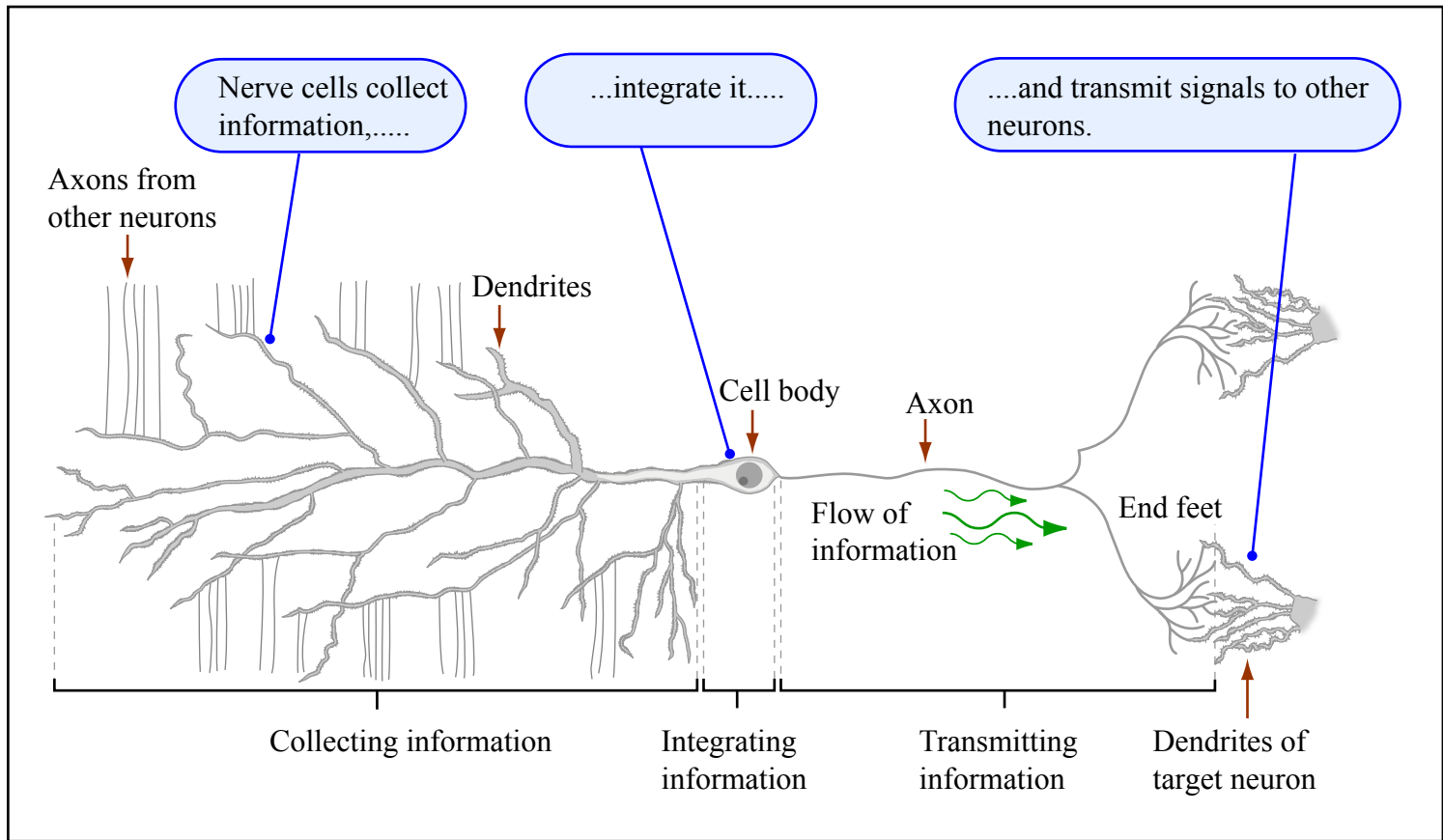


Figure by MIT OpenCourseWare.

Figure 2.24.

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Illustration describing that synapses can occur between dendrites, or between axons and other parts of the neuron such as the cell body, and between axons and capillaries. Synapses can also have no specific target, distributing neurotransmitter into an area.

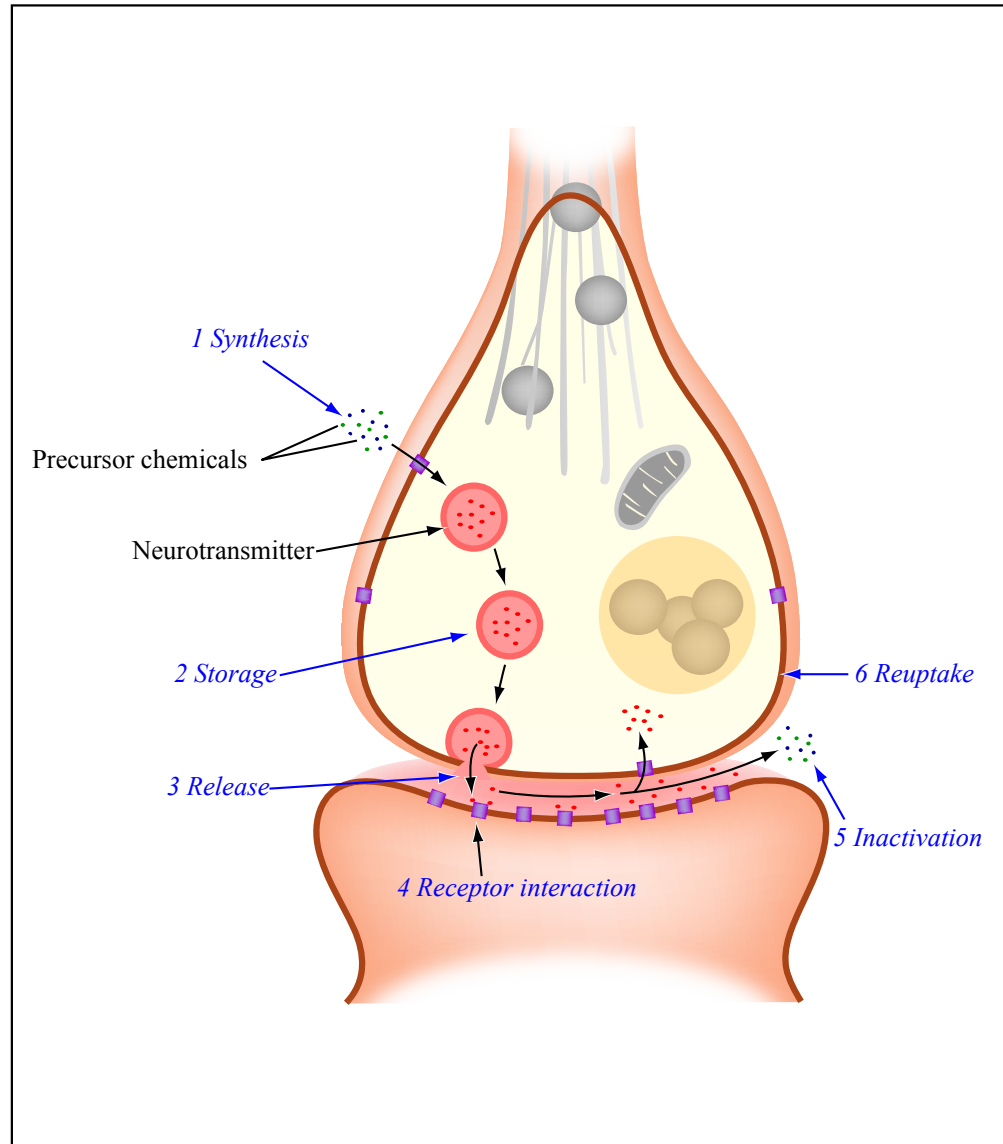


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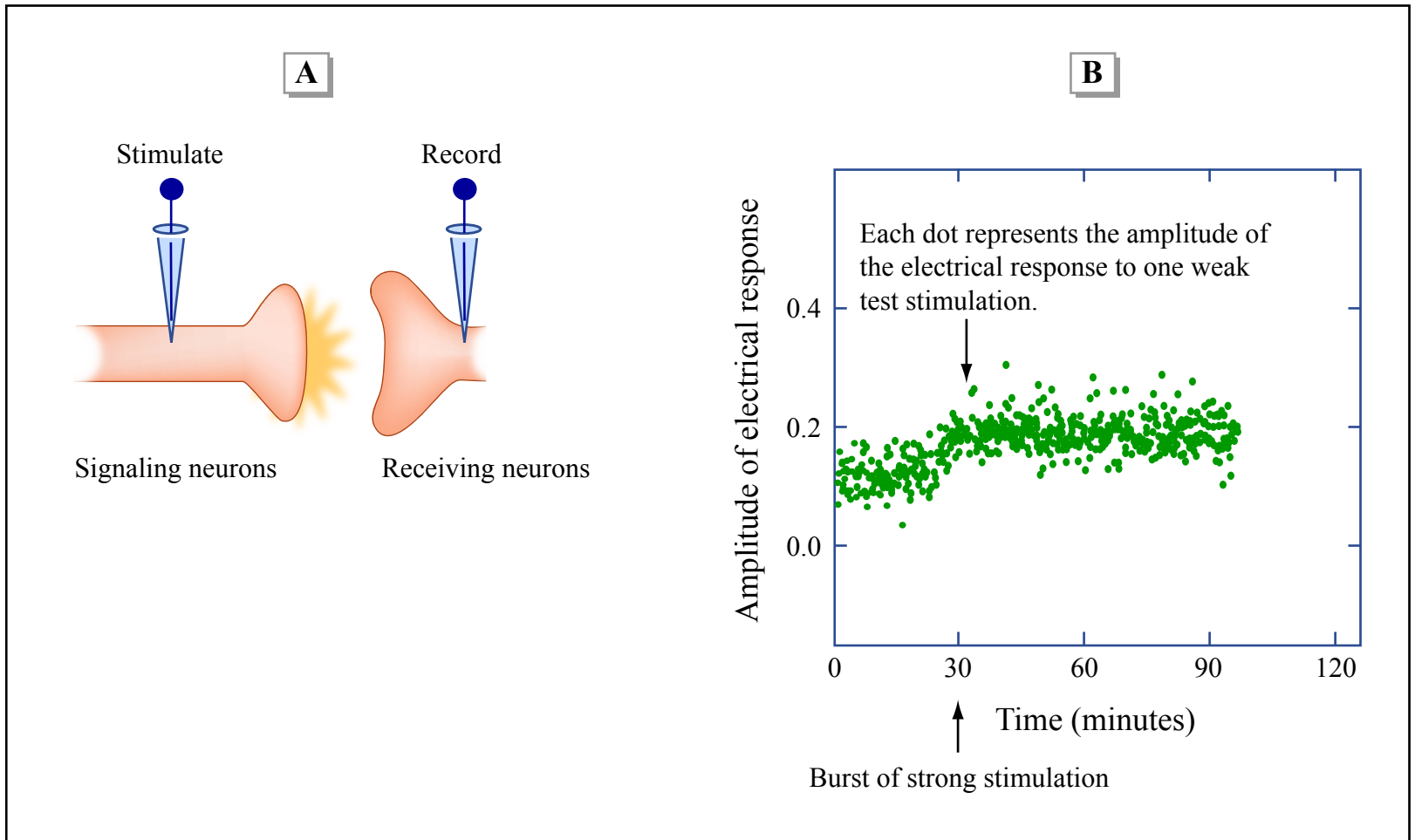
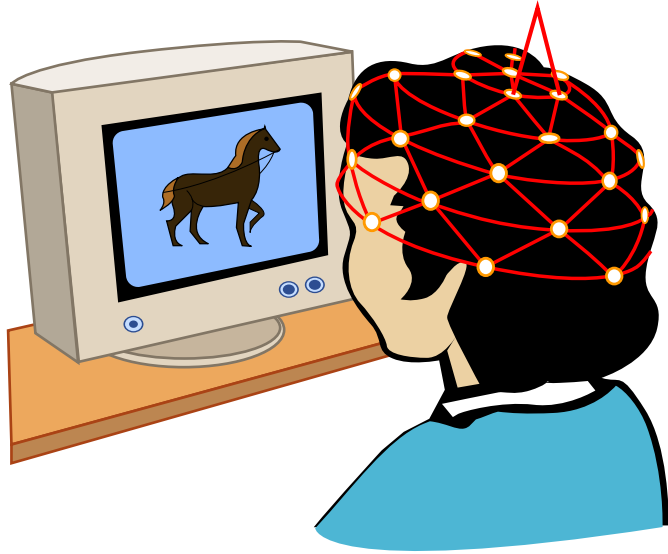
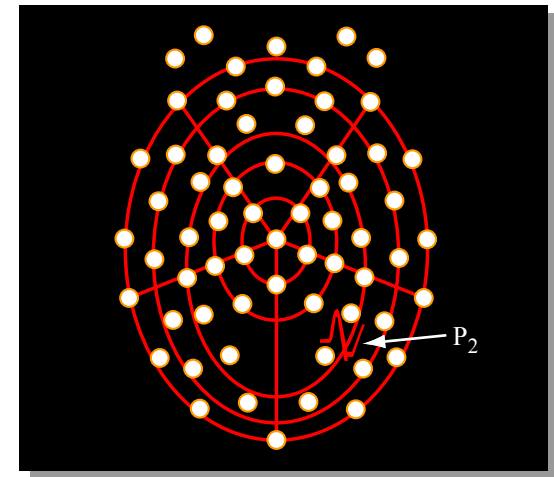


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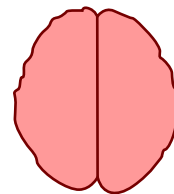
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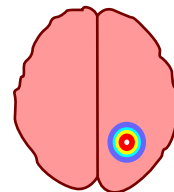
*Electrodes attached to the scalp of the research participant are connected to....*



*a computer display of electrical activity, which shows a large positive ( $P_2$ ) wave at the posterior right side of the head.*



Resting



Viewing

*This electrical activity can be converted into a color representation showing the region most responsive to the stimulus.*

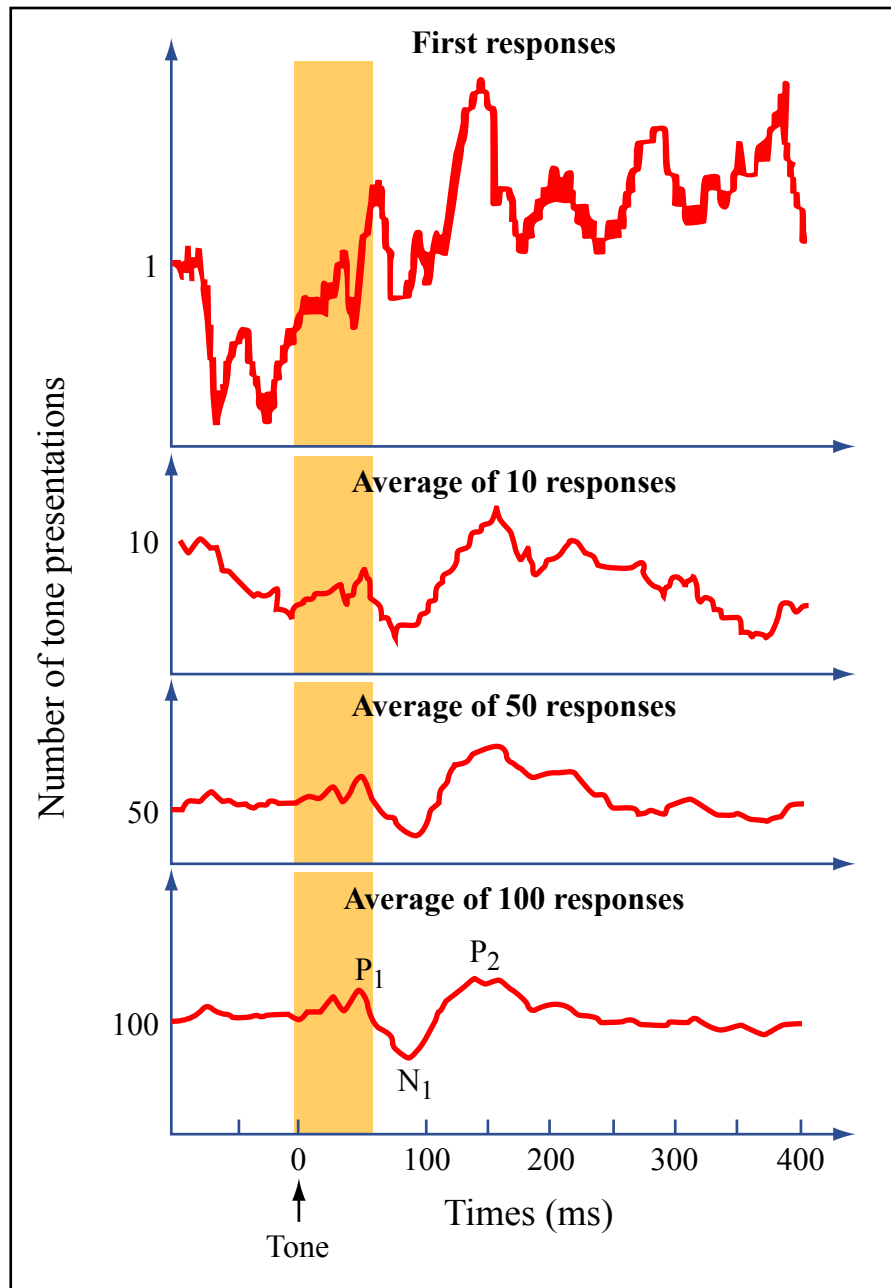


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Figure 2.16.

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Quote from Eccles and McIntyre, 1951, essentially stating that synaptic plasticity in the nervous system (or, the ability of synapses to adapt to use and disuse by adjusting their transmission thresholds) is implicated in discussions about the mechanisms of learning and memory. Discoveries recent in 1951 showed that enduring changes could take place in a monosynaptic junction after a quick burst of repetitive stimuli and consequential neuronal firing (a "tetanus"), a phenomenon which was then dubbed post-tetanic potentiation.