Machine learning introduction
Part I – From neurons to networks

1 – The neuron

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Part I-1 : the neuron

- **Artificial intelligence aims to mimic several properties of human or animal intelligence**

- **This intelligence emerges from the most incredible but also mysterious organ : the brain**
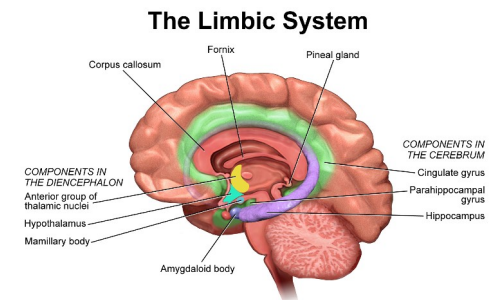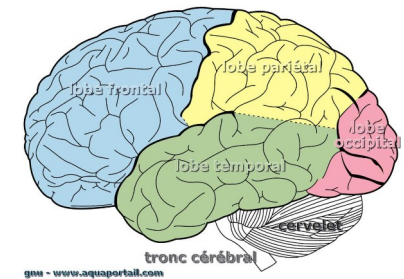
  - **Let's analyze it !**

Part I-1 : the neuron

- **Characteristics of human brain:**
  - ~80-100 billions neurons
  - Equivalent number of *glial cells*
  - ~ 1,5 x 10^{14} connections
  - 10.000 to 50.000 neurons and 100 à 500 millions connections by mm^3
  - Different areas related to specific functions
    - Cortex (vision, hearing, touch, localization, motor coordination, cognitive functions)
    - Lymbic system (emotions, navigation, memory, hormone control)
    - Brain stem (reflexes, body posture, eye control)

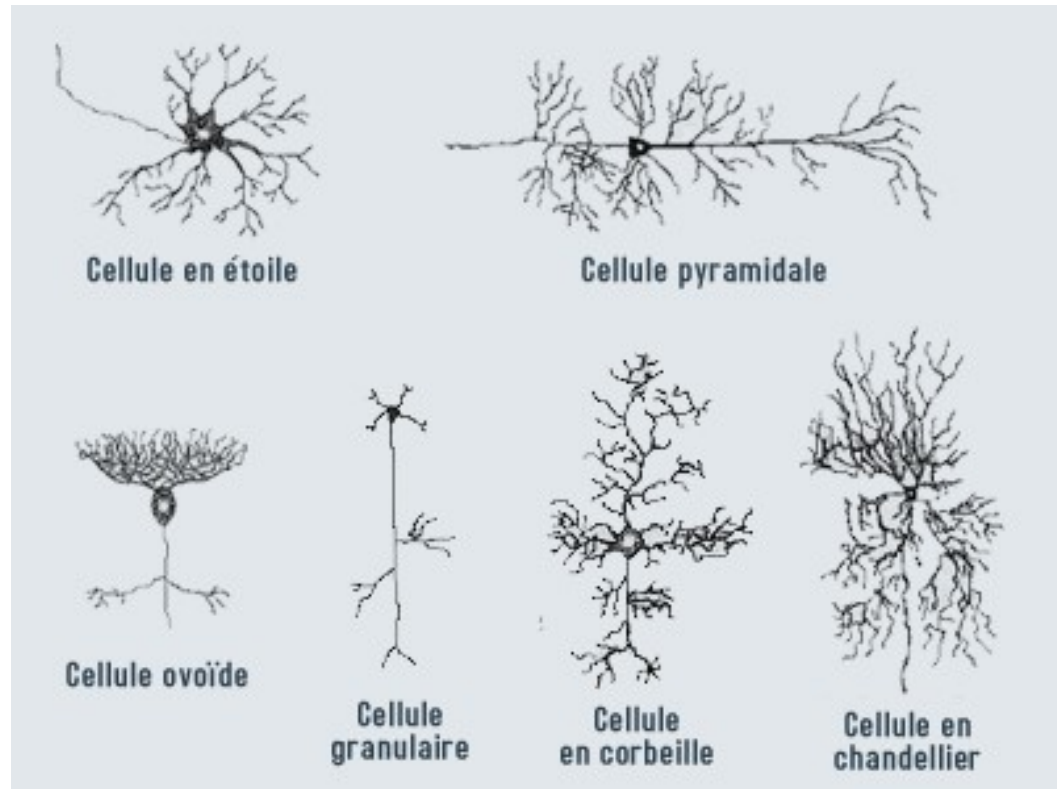 - **The brain is not a tank of neurons !**

- **Even animals' brains are beyond computer's possibilities:**
  - Cat : 760 millions neurons
  - Mouse : 71 millions
  - frog : 16 millions
  - fish : 10 millions
  - bee : 960 000 (1 billion connections)
  - fly : 250 000 (10 millions connections)

Part I-1 : the neuron

There are many types (>200) of neurons, with their own working principles

Cellule en étoile

Cellule pyramidale

Cellule ovoïde

Cellule granulaire

Cellule en corbeille
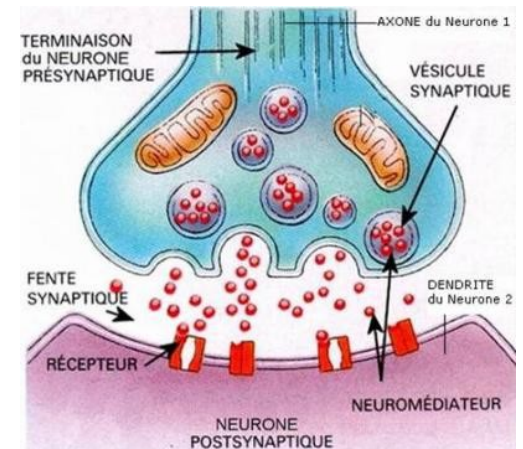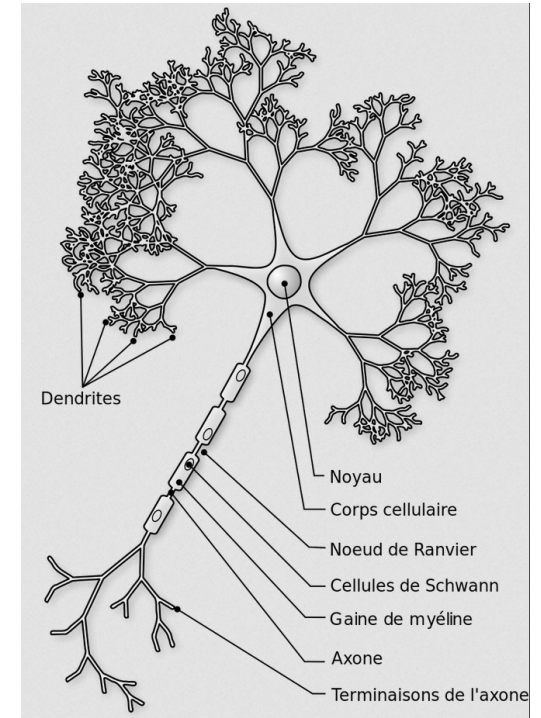
Cellule en chandellier

New types are regularly discovered → last one was discovered in 2018 (called rosehip neurons)

Part I-1 : the neuron

The most common neuron type (and thus the most known) are *multipolar neurons*

- – Anatomy of the neuron:
    - A body (also called pericaryon or soma)
    - *Dendrites* (around 7000 per neuron) → inputs
    - A unique *axon* → output

- – Neurons communicate through *synapses*
    - Axon to dentride connection
    - Signal is contactless:
        - – The axon emits chemical neurotransmitters
        - – The dendrite receives signal through neuroreceptors
    - The strength of the connection depends on the amount of neurotransmitter emitters/receptors in the synapse

- – When receiving pulse signals, the neuron tension increase (presence of ions)
    - When reaching -55mV, the neuron emits an electric impulsion of +100mV through its axon, sending a signal to connected neurons
    - Information is encoded in synapses

Dendrites
Noyau
Corps cellulaire
Noeud de Ranvier
Cellules de Schwann
Gaine de myéline
Axone
Terminaisons de l'axone

AXONE du Neurone 1
TERMINAISON du NEURONE PRÉSYNAPTIQUE
VÉSICULE SYNAPTIQUE
FENTE SYNAPTIQUE
DENDRITE du Neurone 2
RÉCEPTEUR
NEUROMÉDIATEUR
NEURONE POSTSYNAPTIQUE

Part I-1 : the neuron

Synaptic learning

- Most common mechanism: Hebb principle (Donald Hebb , 1949)

  - Neurons triggering simultaneously reinforce their synaptic connection

    - When two neurons trigger simultaneously, the number of neurotransmitter emitter/receptor increases to facilitate the signal reception.

    - When two neurons are strongly connected, the signal sent by the first neuron is more likely to trigger the second neuron, that will transmit the signal to next neurons

- Other mechanisms are used by other types of neurons