Development of Complex Curricula for Molecular Bionics and Infobionics Programs within a consortial* framework**

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**Molekuláris bionika és Infobionika Szakok tananyagának komplex fejlesztése konzorciumi keretben

***A projekt az Európai Unió támogatásával, az Európai Szociális Alap társfinanszírozásával valósul meg.

BASICS OF NEUROBIOLOGY

Neurobiológia alapjai

NERVOUS TISSUE

(Idegszövet)

ZSOLT LIPOSITS

MAIN CHARACTERISTICS NERVOUS TISSUE

THE NERVOUS TISSUE RECEIVES INFORMATION FROM THE ENVIRONMENT

PROCESSES THE INCOMING DATA AND DISPATCHES EXECUTIVE COMMANDS THAT REGULATE THE BASIC FUNCTIONS OF THE BODY AND ADJUST THEM TO THE CHANGING INTERNAL AND EXTERNAL CONDITIONS

COMPOSED OF TWO MAJOR CELL TYPES: NEURONS AND GLIAL CELLS

NEURONS EXHIBIT PROCESSES (DENDRITES, AXONS) THAT ARE USED FOR NETWORKING AND COMMUNICATION

NEURONS ARE EXCITABLE CELLS THAT MAINTAIN A -70 mV RESTING POTENTIAL DUE TO THE UNEVEN DISTRIBUTION OF K^+, Na^+ AND Cl^- IONS ACROSS THE PLASMA MEMBRANE. NERST EQUATION, GOLDMAN-HODGKIN-KATZ EQUATION

INCREASE IN THE K^+ AND Na^+ CONDUCTANCE EVOKES ACTION POTENTIAL THAT RESULTS IN ELECTRIC OR CHEMICAL SIGNALLING AFFECTING THE MEMBRANE PROPERTIES OF THE SYNAPTICALLY COUPLED NEURONS.

GLIAL CELLS EXIST IN STRUCTURAL AND FUNCTIONAL SYMBIOSIS WITH NEURONS

STRUCTURAL DOMAINS OF NEURONS

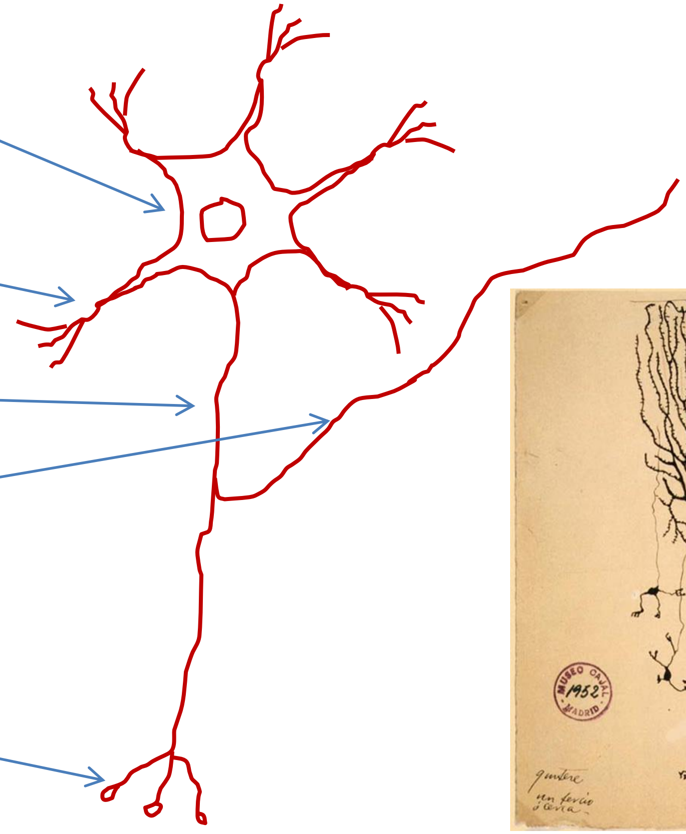
CELL BODY (PERIKARYON)

DENDRITIC PROCESS

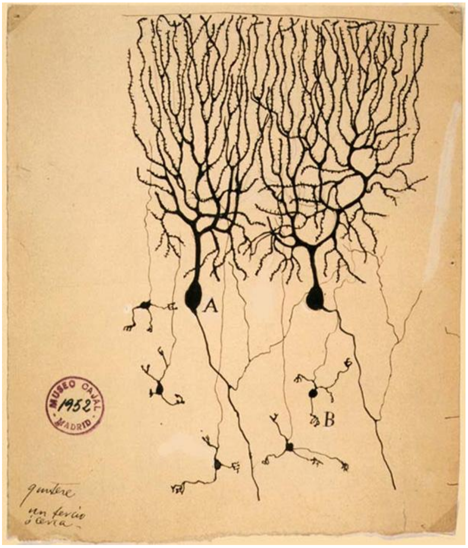
AXON PROCESS

AXON COLLATERAL

AXON TERMINAL



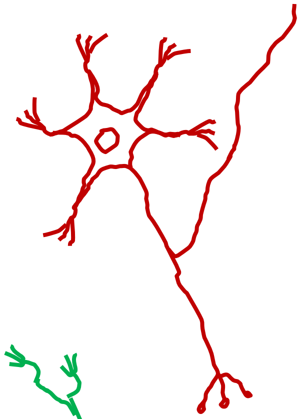
NEURON RECONSTRUCTION
3D ORIENTATION



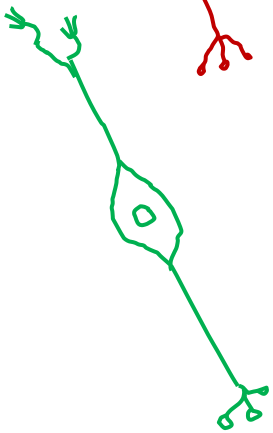
Drawing by Santiago Ramón y Cajal of cerebellar neurons
(A) Purkinje cells. (B) Granule cells.

BASIC NEURON TYPES

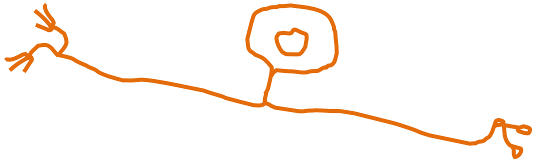
MULTIPOLAR NEURONS. MOST COMMON TYPE WITH AN EXTENDED, BRANCHING DENDRITIC TREE. MOTONEURONS OF THE SPINAL CORD



BIPOLAR NEURONS. POSSESS A DENDRITIC PROCESS AND AN AXON, ORIGINATING FROM THE OPPOSITE POLES OF THE CELL. SENSORY NEURONS OF THE VESTIBULAR GANGLION



PSEUDO-UNIPOLAR NEURONS. THE DENDRITE AND THE AXON ARISE FROM A COMMON STEM OF THE NEURON. SENSORY NEURONS OF THE SPINAL GANGLION



1. DENDRITIC TREE. COLLECTION OF DENDRITES. EXTENSIVE BRANCHING. EXHIBITS DENDRITIC SPINES. RECEIVES AFFERENT AXON TERMINALS FROM OTHER NEURONS

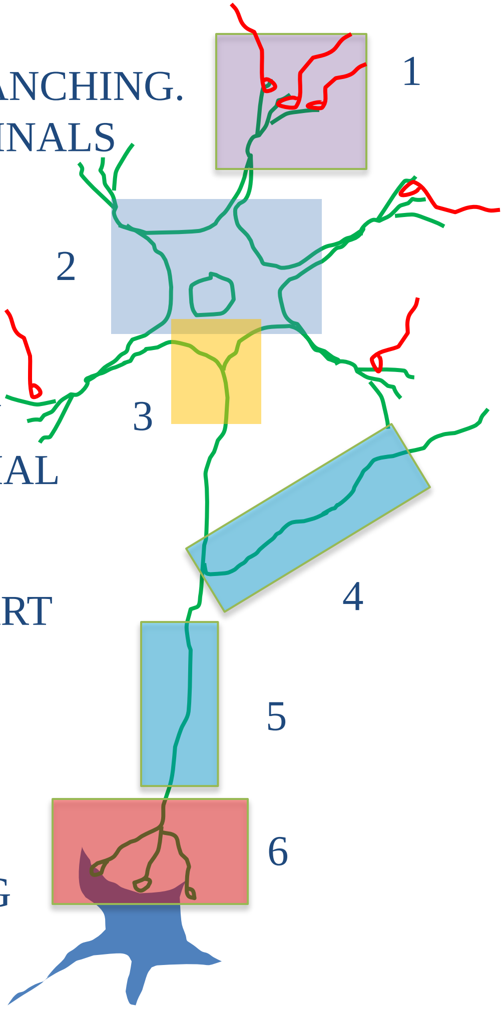
2. CELL BODY. RICH IN CELL ORGANELLES. ENSURES PROTEIN PRODUCTION. ORGANIZES INTRACELLULAR TRAFFICKING

3. AXON HILLOCK. SITE FOR AXON ORIGIN. SHOWS HIGH DENSITY OF VOLTAGE-DEPENDENT SODIUM CHANNELS. ACTION POTENTIAL INITIATION

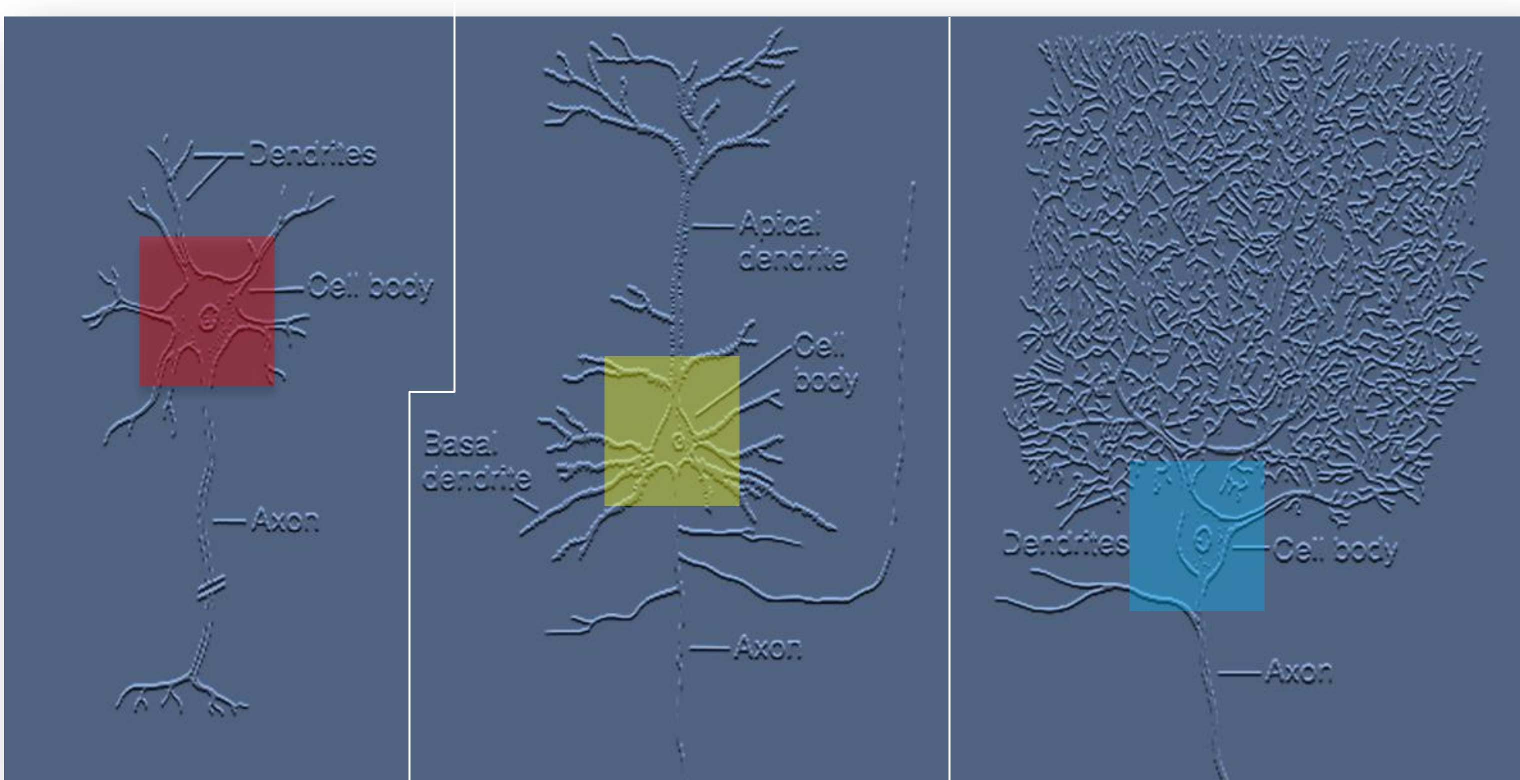
4. AXON COLLATERAL. BRANCH OF THE AXON PROCESS. TAKES PART IN LOCAL NEURONAL NETWORKS

5. AXON. EFFERENT PROCESS OF NEURON. PROPAGATES ACTION POTENTIALS. ENSURES TRANSPORT MECHANISMS

6. AXON TERMINAL. THE FINAL SEGMENT OF THE AXON SPLITTING INTO FINE-CALIBER PROCESSES THAT COMMUNICATE WITH OTHER ELEMENTS. RELEASES NEUROMESSENGERS



DIFFERENT PHENOTYPES AND CHEMOTYPES OF MULTIPOLAR NEURONS

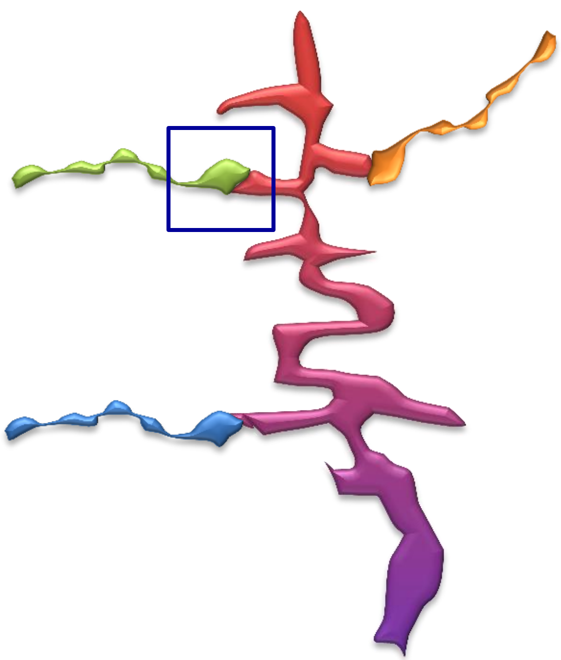


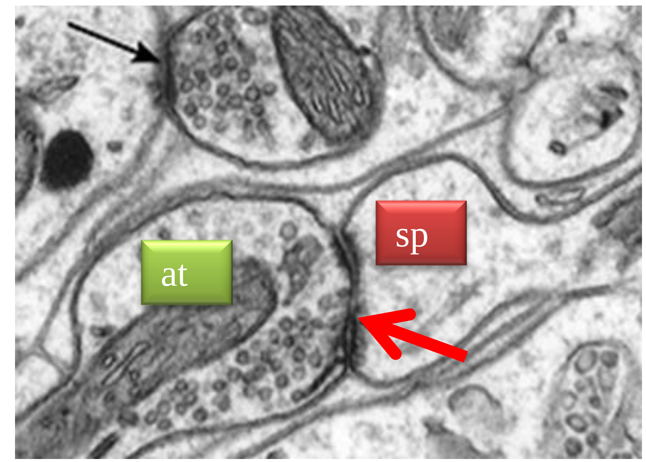
CHOLINERGIC MOTONEURON

GLUTAMATERGIC PYRAMIDAL CELL

GABAERGIC PURKINJE CELL

AXO-SPINOUS SYNAPTIC COMMUNICATION

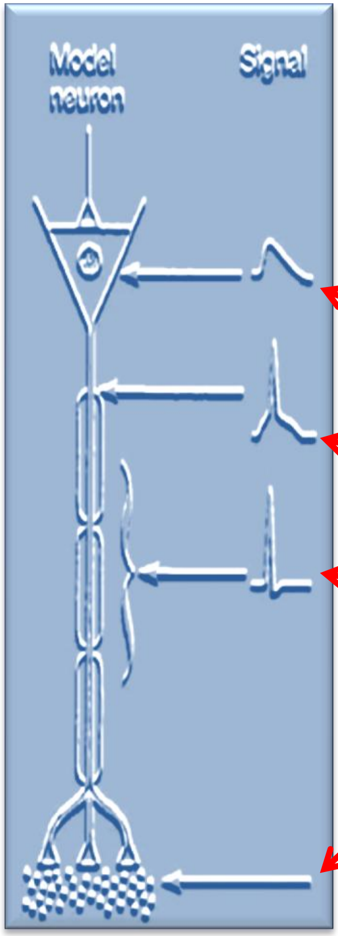




1. DENDRITE FORMING DENDRITIC SPINES THAT RECEIVE TERMINATING AXONS

2. ULTRASTRUCTURAL SCHEME OF AN AXO-SPINOUS SYNAPSE

2. SYNAPSE (ARROW) FORMED BY AN AXON TERMINAL (at) ON A DENDRITIC SPINE (sp)



MAIN CELLULAR FUNCTIONS OF NEURONS

1. GENERATE INTRINSIC ACTIVITY
2. RECEIVE EXTRINSIC, SYNAPTIC INPUTS
3. INTEGRATE INTRINSIC AND EXTRINSIC SIGNALS
4. ENCODE THE PATTERN OF OUTPUT
5. DISTRIBUTE INFORMATION VIA SYNAPSES

MEMBRANE POTENTIAL AND ACTION POTENTIAL

MEASURING THE RESTING MEMBRANE POTENTIAL: -90 mV

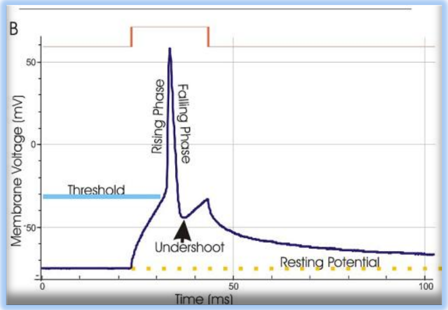
THE ACTIVE TRANSPORT OF SODIUM AND POTASSIUM IONS THROUGH THE MEMBRANE: THE SODIUM-POTASSIUM PUMP

LEAKAGE OF SODIUM AND POTASSIUM THROUGH THE MEMBRANE

CONTRIBUTION OF ION LEAKAGE AND THE SODIUM-POTASSIUM PUMP TO THE RESTING POTENTIAL

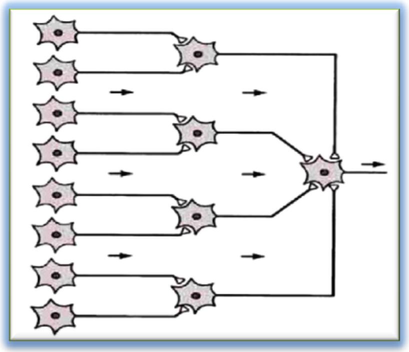
THE 3 PHASES OF ACTION POTENTIAL: RESTING, DEPOLARIZATION AND REPOLARIZATION STAGES

CORRELATION OF ACTION POTENTIAL STAGES WITH THE OPERATION OF THE VOLTAGE-GATED SODIUM AND POTASSIUM CHANNELS

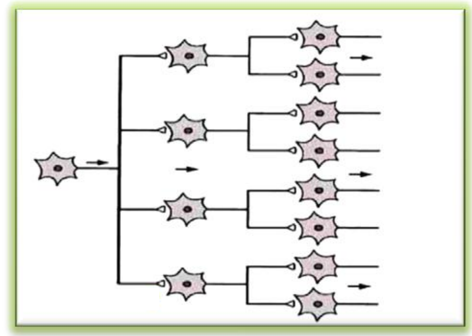


CHARACTERISTICS OF NEURONAL NETWORKS

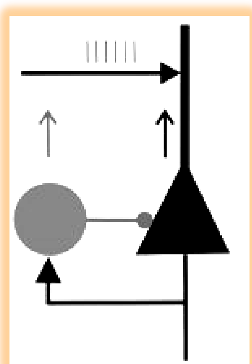
CONVERGENT NEURONAL PATHWAY FOR NARROWING INFORMATION FLOW



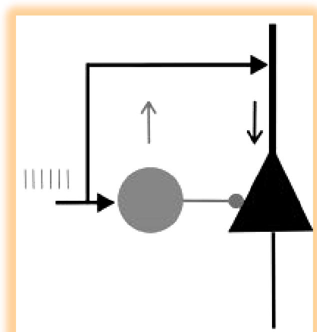
DIVERGENT NEURONAL PATHWAY FOR WIDENING INFORMATION FLOW



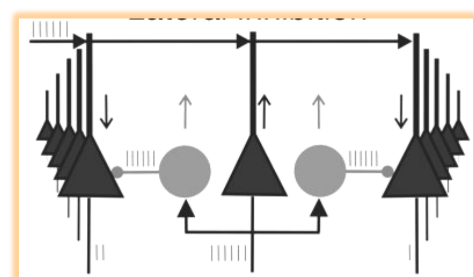
FEEDBACK INHIBITION



FEED FORWARD INHIBITION



LATERAL INHIBITION



Neural inhibition
From Scholarpedia
Peter Jonas and Gyorgy Buzsaki (2007), Scholarpedia, 2(9):3286.

NEURON DOCTRINE

NEURONS ARE DOMINANT CONSTITUENTS OF THE NERVOUS TISSUE.
THEY SERVE IN MULTIPLE CAPACITIES

STRUCTURAL UNIT. NEURONS ARE INDIVIDUAL ENTITIES, TOTALLY COVERED BY CELL MEMBRANE, 15-20 nM WIDE INTERNEURONAL SPACE SEPARATES THEM

DEVELOPMENTAL UNIT. NEURONS DEVELOP FROM SPHERICAL OR COLUMNAR NEUROEPITHELIAL CELLS OF THE NEURAL TUBE, NEURAL CREST AND THE PLACODE PLATES. DIFFERENTIATED, MATURE NEURONS DO NOT DIVIDE

TROPHIC UNIT. THE CELL BODY PROVIDES THE GENETIC CODE AND THE DIVERSE BIOCHEMICAL MACHINERIES THAT MAINTAIN THE TROPHIC NEEDS OF THE LONG PROCESSES. NISSL BODIES ARE INDICATIVE OF THE ACTIVE PROTEIN SYNTHESIS IN NEURONS

FUNCTIONAL UNIT. THE INHIBITORY AND EXCITATORY CURRENTS SPREAD IN ALL DIRECTIONS IN THE NEURONAL MEMBRANE . ONCE THE ALL-OR-NONE TYPE ACTION POTENTIAL IS GENERATED IT SPREADS IN THE DIRECTION OF THE AXON TERMINAL

PATHOLOGICAL UNIT. NEURONS GIVE A DIFFERENTIAL RESPONSE TO PATHOLOGICAL CAUSES

HISTODYNAMIC POLARIZATION. THE PREFERRED WAY OF CONDUCTING INFORMATION IN THE AXON IS FROM THE DIRECTION OF THE CELL BODY TOWARD THE AXON TERMINAL