BRAIN VOYAGES

A PROJECT DEVELOPED BY THE CENTER FOR NEUROSCIENCE AND CELL BIOLOGY (CNC) OF THE UNIVERSITY OF COIMBRA, PORTUGAL

COORDINATION AND TEXT:
JOÃO RAMALHO-SANTOS E SARA VARELA AMARAL

ART:
ANDRÉ CAETANO

WITH THE PARTICIPATION OF THE RESEARCHERS:
ANA CRISTINA REGO, ANA LUÍSA CARVALHO, ANA RITA ÁLVARO, CARLA LOPES, CARLOS DUARTE, CLÁUDIA CAVADAS, CLÁUDIA PEREIRA, JOÃO PEÇA, LUANA NAIA, LUÍS PEREIRA DE ALMEIDA, NUNO EMPADINHAS, PAULA MOREIRA, PAULO PINHEIRO, RAMIRO ALMEIDA, RICARDO RODRIGUES, SANDRA MORAIS CARDOSO, SANDRA MOTA

THE **BRAIN** IS OUR MOST COMPLEX ORGAN. IT DEFINES WHO WE ARE AND HOW WE DISCOVER THE WORLD. BUT IT REMAINS LARGELY UNKNOWN, AND IS ONE OF THE GREAT CHALLENGES IN BIOMEDICAL RESEARCH FOR THE 21RST CENTURY.

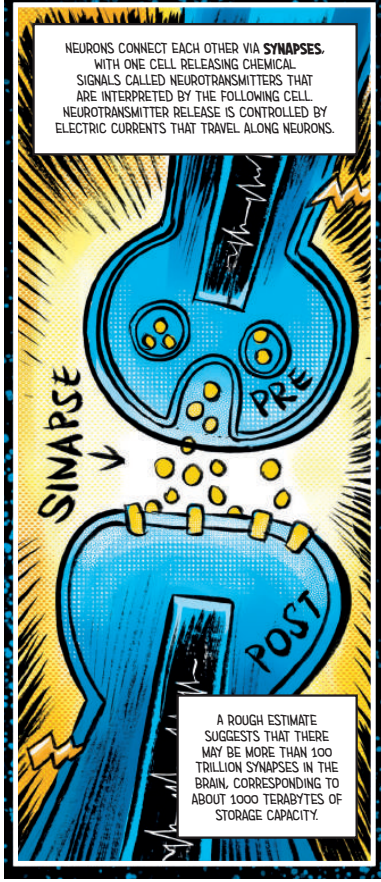
THE MANY FUNCTIONS THAT WE RELY ON TO LIVE, AND APPRECIATE LIFE, ARE ORGANIZED BY THE BRAIN. KEEPING IT FUNCTIONAL IMPLIES CONSTANT MAINTENANCE, AND CONSUMES LARGE AMOUNTS OF ENERGY..

BESIDES OTHER CELL TYPES, THE BRAIN IS MADE UP BY AROUND ONE HUNDRED BILLION INTERCONNECTED **NEURONS**.

THE SPANISH RESEARCHER **SANTIAGO RAMÓN Y CAJAL** (1852-1934) WAS THE FIRST TO IDENTIFY THIS COMPLEX NETWORK THAT TRANSMITS AND PROCESSS INFORMATION.

FOR NORMAL DEVELOPMENT, A PRECISE NUMBER OF NEURONS MUST BE FORMED, WHICH THEN MIGRATE TO DISTINCT BRAIN REGIONS. NO MORE, NO LESS, AND ALL IN THE RIGHT PLACE.

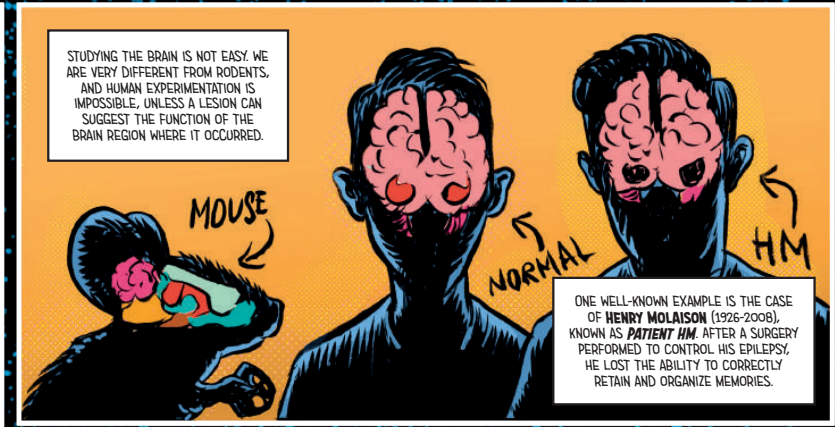
NEURONS CONNECT EACH OTHER VIA **SYNAPSES**, WITH ONE CELL RELEASING CHEMICAL SIGNALS CALLED NEUROTRANSMITTERS THAT ARE INTERPRETED BY THE FOLLOWING CELL. NEUROTRANSMITTER RELEASE IS CONTROLLED BY ELECTRIC CURRENTS THAT TRAVEL ALONG NEURONS.



A ROUGH ESTIMATE SUGGESTS THAT THERE MAY BE MORE THAN 100 TRILLION SYNAPSES IN THE BRAIN, CORRESPONDING TO ABOUT 1000 TERABYTES OF STORAGE CAPACITY.

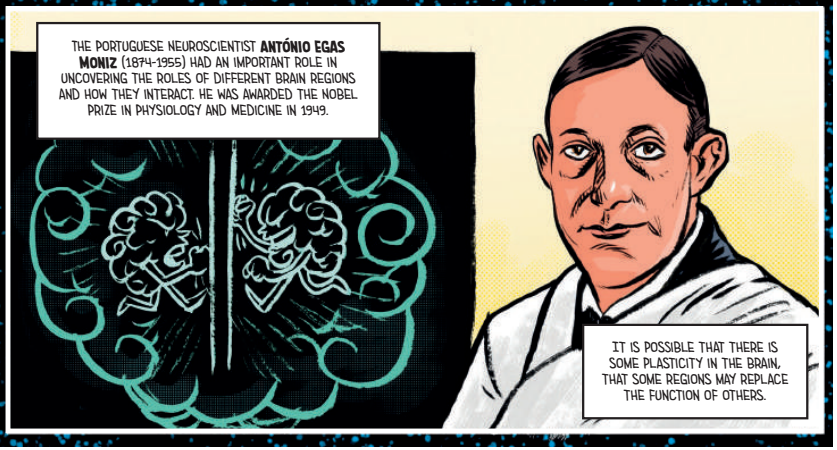
THESE CONNECTIONS BETWEEN NEUROS ARE NOT TOTALLY FIXED, AND CAN BE REARRANGED THROUGHOUT LIFE. THIS **SYNAPTIC PLASTICITY** UNDERLIES DIFFERENT TYPES OF BEHAVIORS.

STUDYING THE BRAIN IS NOT EASY. WE ARE VERY DIFFERENT FROM RODENTS, AND HUMAN EXPERIMENTATION IS IMPOSSIBLE, UNLESS A LESION CAN SUGGEST THE FUNCTION OF THE BRAIN REGION WHERE IT OCCURRED.



ONE WELL-KNOWN EXAMPLE IS THE CASE OF **HENRY MOLAISON** (1926-2008), KNOWN AS ***PATIENT HM***. AFTER A SURGERY PERFORMED TO CONTROL HIS EPILEPSY, HE LOST THE ABILITY TO CORRECTLY RETAIN AND ORGANIZE MEMORIES.

THE PORTUGUESE NEUROSCIENTIST **ANTÓNIO EGAS MONIZ** (1874-1955) HAD AN IMPORTANT ROLE IN UNCOVERING THE ROLES OF DIFFERENT BRAIN REGIONS AND HOW THEY INTERACT. HE WAS AWARDED THE NOBEL PRIZE IN PHYSIOLOGY AND MEDICINE IN 1949.



IT IS POSSIBLE THAT THERE IS SOME PLASTICITY IN THE BRAIN, THAT SOME REGIONS MAY REPLACE THE FUNCTION OF OTHERS.

EATING HABITS, EXERCISE (BOTH PHYSICAL AND INTELLECTUAL), AND REGULAR SLEEP ARE IMPORTANT TO MAINTAIN THE BRAIN ACTIVE.

ZZZ

BRAIN

ONE OF THE MOST FASCINATING AND INTERDISCIPLINARY (AND CONTROVERSIAL) AREAS OF BRAIN RESEARCH INVOLVES **NEURONAL CIRCUITS**, RESPONSIBLE FOR COMPLEX SOCIAL BEHAVIORS.

AUTISM, **SCHIZOPHRENIA**, **HYPERACTIVITY** AND OTHER NEUROPSYCHIATRIC DISORDERS RESULT FOR COMPROMISED CONNECTIONS BETWEEN NEURONS.

THIS ALSO HAPPENS IN NEURODEGENERATIVE DISORDERS, SUCH AS **ALZHEIMER'S**, **PARKINSON'S**, **HUNTINGTON'S** OR **MACHADO-JOSEPH DISEASE**, WHERE THE MAIN REASON FOR COMMUNICATION BREAKDOWN IS NEURON DEATH.

CUTTING-EDGE RESEARCH IN THIS FIELD ALSO INCLUDES THE **GUT-BRAIN AXIS**, AND HOW THE PROPORTIONS OF PATHOGENIC AND HELPFUL BACTERIA IN THE GUT MAY INFLUENCE BRAIN ACTIVITY, VIA THE **VAGUS NERVE**.

VAGUS NERVE

AND EVEN INFLUENCE THE PROGRESSION OF CONDITIONS SUCH AS **PARKINSON'S DISEASE**.

NEURODEGENERATIVE DISORDERS MAY AFFECT DIFFERENT PATIENTS IN VERY DIFFERENT WAYS. **BIOMARKERS** (SUBSTANCES DETECTED IN BLOOD, URINE SALIVA, CEREBROSPINAL FLUID) MAY HELP PREDICT DISEASE PROGRESSION, OR MONITOR THE SUCCESS OF THERAPEUTIC STRATEGIES.

QUALITY CONTROL IS ESSENTIAL FOR PROPER BRAIN FUNCTION. THE FORMATION AND DEPOSIT OF **PROTEIN AGGREGATES** IN NEURONS IS CORRELATED WITH CELL DEATH, AND WITH COGNITIONAND MOTOR PROBLEMS.

THIS TAKES PLACE IN **ALZHEIMER'S**, **PARKINSON'S**, **HUNTINGTON'S** OR **MACHADO-JOSEPH DISEASE**, OFTEN WITH A STRONG GENETIC COMPONENT THAT RUNS IN FAMILIES.

ANOTHER IMPORTANT ISSUE IS THE ENERGY AVAILABLE FOR BRAIN ACTIVITY, PRODUCED BY **MITOCHONDRIA**, THE "POWER PLANTS" OF CELLS.

MITOCHONDRIAL DAMAGE IS ALSO INVOLVED IN NEURODEGENERATION, AND THIS PROBLEM CAN BE WORSENED BY CONDITIONS SUCH AS **DIABETES**.

PREVENTING NEURON DEATH, REMOVING PROTEIN AGGREGATES, BOOSTING **MITOCHONDRIAL FUNCTION**, OR CONTROLLING INFLAMMATION ARE SOME OF THE THERAPEUTIC STRATEGIES FOR BRAIN DISORDERS

BUT EVERYTHING THAT HELPS EXERCISE THIS ORGAN CAN BE USEFUL.

WHEN A GENETIC COMPONENT IS INVOLVED **GENE THERAPY** MAY ALSO BE POSSIBLE, BY REPLACING AN ALTERED GENE, OR REDUCING ITS ACTIVITY.

RESEARCH IN NEUROSCIENCES PROMISES TO UNCOVER MUCH MORE ON THE BRAIN THE COMING DECADES, THUS ALLOWING **NEW GENERATIONS OF RESEARCHERS** TO EMBARK ON THE VOYAGES OF THEIR LIVES.

BUT WE MUST ALSO REMEMBER THAT THE **ENORMOUS POTENTIAL** OF THIS ORGAN IS PRESENT IN EACH AND EVERY ONE OF US. IT SHOULD BE UNLEASHED DAILY, TO HELP US FIND THE RIGHT SOLUTIONS FOR A BETTER FUTURE.