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199

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and Kamen G. Usunoff

**The Subthalamic
Nucleus
Part II: Modelling
and Simulation
of Activity**

With 54 Figures

 Springer

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List of Contents

1	Introduction	1
2	The Basal Ganglia	1
2.1	Pathways Within the Basal Ganglia	2
2.1.1	Direct Pathway	2
2.1.2	Indirect Pathway	2
2.1.3	Hyperdirect Pathway	4
2.1.4	Role of the Direct, Indirect, and Hyperdirect Pathways	4
2.1.5	Role of Dopamine in the Direct and Indirect Pathways	6
2.1.6	Conduction Times of Pathways	6
2.2	Parkinson's Disease	6
2.2.1	Direct and Indirect Pathways in PD	7
2.2.2	Changes in Neuronal Firing Rate in PD	8
2.2.3	Changes in Neuronal Firing Pattern in PD	9
2.3	Deep Brain Stimulation	9
2.3.1	Which Neuronal Elements Are Influenced by DBS?	11
2.3.2	Mechanisms of DBS: Hypotheses	11
3	STN Activity Recorded in Vitro: Brain Slices	14
3.1	Spontaneous Activity	15
3.1.1	Single-Spike Mode	15
3.1.2	Burst-Firing Mode	17
3.2	Depolarizing and Hyperpolarizing Inputs	19
3.2.1	Plateau Potential	21
3.2.2	Low-Threshold Spike	22
3.3	Ionic Mechanisms of a Plateau Potential	23
3.4	Synaptic Inputs	25
3.5	High-Frequency Stimulation of STN Cells	26
3.6	Intrinsic Versus Extrinsic Properties: Bursts	27
3.6.1	Definition of Bursts	27
3.6.2	Burst Detection Algorithms	28
3.6.3	Network Bursts Using Burst and Phase Profiles	30
4	STN Activity Recorded in Vitro: Dissociated Cell Cultures	31
4.1	Experimental Set-up	31
4.1.1	Cell Culture	33
4.1.2	Measurement Set-up	33
4.2	Spontaneous Activity	33

4.3	Addition of Acetylcholine	35
4.4	Electrical Stimulation	37
5	STN Cell Models and Simulation of Neuronal Networks	40
5.1	Otsuka's Model	40
5.1.1	Membrane Dynamics	41
5.1.2	Spontaneous Activity	43
5.1.3	Plateau Potential Generation	45
5.2	Terman and Rubin's Model	52
5.2.1	Membrane Dynamics	52
5.2.2	Spontaneous Activity	53
5.2.3	Rebound Bursts	56
5.3	Comparison of the Otsuka Model with the Terman/Rubin Model	58
5.4	The Multi-compartment STN Model of Gillies and Willshaw	63
5.4.1	Membrane Dynamics	63
5.4.2	Activity Patterns	64
5.5	Intra-nuclear Network Models	66
5.6	Inter-nuclear Network Models	67
5.6.1	GPe-STN Network	67
5.6.2	GPe-STN-GPI-Thalamus Network	71
6	Comparison of Part I and Part II	75
6.1	Recurrent STN Axons	75
6.2	Inter-neurons in the STN	75
6.3	Fibre Tracts around and in the STN	75
6.4	Ca ²⁺ Receptors	76
6.5	Three-Dimensional Modelling	76
6.6	Types of Projection Neurons	76
6.7	Neurotransmitter Input Versus Receptors in the STN	77
6.8	The Pedunculopontine Nucleus	77
6.9	Nigro-subthalamic Connections	77
6.10	Another Cortico-subthalamic Loop	78
6.11	Nissl-Based Subdivision of the STN	78
Appendix 1	Model Parameter Values Otsuka et al. 2004	78
Appendix 2	Model Parameter Values Terman et al. 2002; Rubin and Terman (2004)	79
References	81
Index	87

Abstract

Part I of *The Subthalamic Nucleus* (volume 198) (STN) accentuates the gap between experimental animal and human information concerning subthalamic development, cytology, topography and connections. The light and electron microscopical cytology focuses on the open nucleus concept and the neuronal types present in the STN. The cytochemistry encompasses enzymes, NO, glial fibrillary acidic protein (GFAP), calcium binding proteins, and receptors (dopamine, cannabinoid, opioid, glutamate, γ -aminobutyric acid (GABA), serotonin, cholinergic, and calcium channels). The ontogeny of the subthalamic cell cord is also reviewed. The topography concerns the rat, cat, baboon and human STN. The descriptions of the connections are also given from a historical point of view. Recent tracer studies on the rat nigro-subthalamic connection revealed contralateral projections. This monograph (Part II of the two volumes) on the subthalamic nucleus (STN) starts with a systemic model of the basal ganglia to evaluate the position of the STN in the direct, indirect and hyperdirect pathways. A summary of in vitro studies is given, describing STN spontaneous activity as well as responses to depolarizing and hyperpolarizing inputs and high-frequency stimulation. STN bursting activity and the underlying ionic mechanisms are investigated. Deep brain stimulation used for symptomatic treatment of Parkinson's disease is discussed in terms of the elements that are influenced and its hypothesized mechanisms. This part of the monograph explores the pedunculopontine-subthalamic connections and summarizes attempts to mimic neurotransmitter actions of the pedunculopontine nucleus in cell cultures and high-frequency stimulation on cultured dissociated rat subthalamic neurons. STN cell models – single- and multi-compartment models and system-level models are discussed in relation to subthalamic function and dysfunction. Parts I and II are compared.

Abbreviations

A	Fields of Sano
A	Adenosine receptor
A8,A9	Catecholaminergic areas
ABC	Avidin-biotin-HRP complex
Alent	Ansa lenticularis
AMPA	α -Amino-3-hydroxy-5-methyl-4-isoxazole-propionic acid
Am(g)	Amygdala
Apt	Anterior pretectal nucleus: dorsal (AD), medial (AM), and ventral (AV) parts
APV	D-2-Amino-5-phosphono-valerate
AWSR	Array-wide spiking rate
AV	Anterior thalamic nucleus
BAPTA	1,2-bis(2-Aminophenoxy)-ethane- <i>N,N,N',N'</i> -tetraacetic acid
bc	Brachium conjunctivum
bci	Brachium of the colliculus inferior
BDA	Biotinylated dextran amine
BG	Basal ganglia
BI	Burst index
BIP	Burst intensity product
bp	Brachium pontis
CaBP	Calcium binding proteins
CB	Cannabinoid receptor
CB	Calbindin
CC	Corpus callosum
cd	Nucleus caudatus
Ce	Capsula interna
ChII	Chiasma opticum
CG	Central grey
Ci	Capsula interna
ci	Capsula interna
Cl	Corpus Luysii
cl	Contralateral

cla	Clastrum
Cm	Corpus mamillare
CM	Centre median
Cml	Ganglion laterale corp. mamillare
Cmm	Ganglion mediale corp. mamillare
Coa	Commissural anterior
Coha	Commissura hypothalamica anterior
Cop	Commissura posterior
Cospm	Commissura supramamillaris
cp	Pedunculus cerebri
CR	Calretinin
Cu	Cuneiform nucleus
Csth	Corpus subthalamicum
ctb	Central tegmental tract of von Bechterew
ctt	Central tegmental tract
δ	Opioid receptor
d	Vesicle containing dendrites
D	Dopamine receptor
DA	Dopamine
Dbc	Decussation of brachium conjunctivum
DBS	Deep brain stimulation
dcv	Dense core vesicle terminals
DIV	Days in vitro
Dlx1/2	Homeobox gene
DNQX	6,7-Dinitroquinoxaline-2,3-dione
E	Embryonic day
EP	Nucleus entopeduncularis
F1	Flat type 1 (boutons)
F2	Flat type 2 (boutons)
Fhy	Fasciculus hypophyseos
Fmp	Fasciculus mamillaris princeps
Fo	Fornix
Fsp	Fasciculus subthalamico-peduncularis
fp	Fibrae perforantes
frtf	Fasciculus retroflexus Meynerti
Fu	Fasciculus uncinatus
GABA	γ -Aminobutyric acid
GAD	Glutamic acid decarboxylase
GAT	Specific high-affinity GABA uptake protein
GC	Gyrus cinguli

GCA	Gyrus centralis anterior
GCP	Gyrus centralis posterior
Gem	Ganglion ectomamillare
GF	Gyrus fusiformis
GH	Gyrus hippocampi
Ghb	Ganglion habenulae
gl	Corpus geniculatum
Glp	Glandula pinealis
glp	Globus pallidus
Glu	Ionotropic glutamate receptor
GP	Globus pallidus
GPe	Globus pallidus externus
GPI	Globus pallidus internus
H,h	H (Haubenfelder) fields of Forel
5HT	5-Hydroxytryptamine
HRP	Horseradish peroxidase
HVA	High voltage activated currents
I	Insula Reilii
i	Nucleus internus gangl. med. corp. mamillaris
il	Ipsilateral
Ins	Insula
ISI	Interspike interval
κ	Opioid receptor κ
Kv3	Type delayed rectifier
L	Calcium channel type
ll	Lemniscus lateralis
Lm	Lemniscus medialis
Lmi	Lamina medullaris interna
Lmm	Lamina medullaris medialis
Lml	Lamina medullaris lateralis
Lp	Posterior limitans thalamic nucleus
LPc	Gyrus paracentralis
LPi	Lobulus parietalis inferior
LR1	Large round type 1 (bouton)
LR2	Large round type 2 (bouton)
LTS	Low-threshold spike
μ	Opioid receptor μ
M,m	Cholinergic receptor
MEA	Midbrain extrapyramidal area