Discussion. La méthode isotopique utilisée dans le présent travail et proposée initialement à la détermination du taux de renouvellement de la NAd dans le cœur[1] parait applicable au canal déférent et à la vésicule séminale. Dans ces deux organes, la disparition de la NAd ^3H s'effectue de façon apparemment monoexponentielle, ce qui, du point de vue cinétique, indique que la NAd ^3H parait être distribuée de façon homogène dans un compartiment unique de NAd endogène.

Les temps de renouvellement de la NAd dans le canal déférent (67,9 h) et la vésicule séminale (33,5 h) paraissent relativement élevés si on les compare aux valeurs obtenues pour d'autres organes périphériques du Rat par utilisation de la même méthode isotopique[9]: ainsi dans le cœur, la rate et le muscle fémoral, les temps nécessaires au renouvellement de la NAd sont de l'ordre de 20 h. Malgré l'importance du temps de renouvellement de la NAd dans le canal déférent, la vitesse de synthèse de l'amine (0,143 µg/g/h) y est relativement élevée comparée à celle de la vésicule séminale (0,045 µg/g/h) et aux valeurs qui ont été rapportées dans la littérature[10,11] pour le cœur de Rat (0,04 à 0,05 µg/g/h).

La lenteur du renouvellement du médiateur sympathique dans ces deux organes génitaux (surtout le canal déférent) suggère que la fréquence des influx sympathiques afférents y est particulièrement faible. Ceci peut rendre compte de certains résultats indiquant que la NAd du canal déférent (et à un degré moindre celle de la vésicule séminale) est relativement résistante vis-à-vis de l'action déplétrice de certains agents pharmacologiques: c'est ainsi que la vitesse de disparition de la NAd après traitement par la réserpine[12] ou la 6-hydroxydopamine[13] est plus lente dans le canal déférent et la vésicule séminale que dans d'autres organes périphériques; or il a été montré[14–16] que la vitesse de déplétion de la NAd dans les tissus réserpinés est fonction de l'activité nerveuse sympathique. Récemment SWEDIN[17] a mis en évidence qu'une inhibition prolongée de la biosynthèse de la NAd par administration de l'ester méthylique de l'α méthylparatyrosine, n'entraine qu'une faible diminution du taux de la NAd endogène dans le canal déférent et la vésicule séminale du Rat. Nous avons nous même observé[18] qu'un traitement de 8 h par l'α méthylparatyrosine (250 mg/kg par voie i.p. suivi 2 h plus tard d'une seconde injection de 100 mg/kg) ne modifie pas de manière significative les teneurs en NAd du canal déférent et de la vésicule séminale et ces résultats ont été interprétés comme la conséquence de la lenteur du renouvellement de la NAd dans ces deux organes.

Summary. The turnover times and the synthesis rates of tissue norepinephrine were determined in the vas deferens and in the seminal vesicle of the rat from the rate of disappearance of H^3-norepinephrine after an i.v. injection of L-H^3-norepinephrine. The labelled amine disappeared from the two organs by a single exponential decline thus behaving kinetically as though it was stored in a single pool.

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8 janvier 1971.

[9] J. BRALET, A. BELEY, A. M. BRALET et J. WEPIERRE, Pflügers Arch. ges. Physiol., à paraître (1971).
[10] B. B. BRODIE, E. COSTA, A. DLABAC, N. H. NEFF et H. H. SMOOKLER, J. Pharmac. exp. Ther. *154*, 493 (1966).
[11] T. C. WESTFALL et H. OSADA, J. Pharmac. exp. Ther. *167*, 300 (1969).
[12] N. O. SJÖSTRAND et G. SWEDIN, Acta physiol. scand. *72*, 370 (1968).
[13] H. THOENEN et J. P. TANZER, Naunyn Schiedebergs Arch. Pharmak. exp. Path. *261*, 271 (1968).
[14] N. T. KÄRKI, M. K. PAASONEN et P. A. VANHAKARTANO, Acta pharmac. tox. *16*, 13 (1959).
[15] N. WEINER, M. PERKINS et R. L. SIDMAN, Nature, Lond. *193*, 137 (1962).
[16] M. BENMILOUD et U. S. VON EULER, Acta physiol. scand. *59*, 34 (1963).
[17] G. SWEDIN, Life Sci. *9*, 1249 (1970).
[18] Résultats non publiés.

Synaptic Glomeruli in the Thalamus of the Rat: Three-Dimensional Relationships between Glomerular Components

Introduction and methods. The synaptic organization of thalamic nuclei concerned with the transmission and modification of sensory information is of interest to both anatomists and physiologists. We are studying (with K. E. WEBSTER) the organization of the rat ventrobasal nuclear complex (VB), and as an adjunct to these studies we have examined three-dimensional relationships between the axon terminals, dendrites, and astrocyte processes that together comprise a synaptic glomerulus[1,2]. We have used electron micrographs of serial sections of aldehyde-perfused VB pars externa to reconstruct the relationships between glomerular components, and have reconstructed one glomerulus in its entirety from an unbroken series of gold Araldite sections.

Results and discussion. Glomeruli in VB vary in shape and size, but are commonly spherical and approximately 5 µm in diameter. They are principally associated with the proximal portions of VB dendrites and are frequently situated at branching points of large dendrites. The most conspicuous component is a large bouton, tightly packed with 50 nm spherical synaptic vesicles, commonly found to originate from a myelinated preterminal axon, and almost certainly the terminal of a lemniscal afferent. The bouton contacts an extensive area of the smooth surface of a dendrite (or dendrites), and is invaginated by protrusions (dendritic excrescences) arising from the dendrite(s). Rarely, the bouton contacts a neuronal soma and is invaginated by somal excrescences identical to those arising from dendrites. Some excrescences are simple, villiform or club-shaped structures that may be no more than 0.5 µm in diameter, and little longer. Others are more complex, branched structures with several 'heads' originating from a single stem.

In the reconstructed glomerulus (Figure) 10 excrescences invaginated the large bouton. 9 of these including 3 compound excrescences, originated from a large (2 µm diameter) primary or stem dendrite (D1), or from a branch of D1 emitted within the glomerular environs (D2, 1 µm at origin). Both D1 and D2 contained conspicuous concentrations of ribosomes and cisternae of

granular endoplasmic reticulum, scattered between longitudinally orientated microtubules. The largest compound excrescence in the glomerulus, with 5 distinct heads, arose from a second dendrite. This dendrite (D3) was smaller than D1 and D2, contained few ribosomes, and unlike D1 and D2, was contacted on its extraglomerular surface by several of the small boutons containing spherical synaptic vesicles that are characteristic of the extraglomerular neuropil. These differences make it probable that D3 was a relatively peripheral dendritic segment, possibly from a different neuron.

The reconstructed glomerulus contained 44 separate and clearly defined type 1 synaptic contacts between the large bouton and the dendritic excrescences, occupying between 5 and 10% of the surface area of the latter. If all the synaptic contacts are activated by an impulse arriving at the bouton, the amplification achieved would result in a very powerful excitatory effect upon the postsynaptic neuron. No additional synapses were established between the large bouton and any other glomerular or extraglomerular dendrite or axon.

The entire contact area between the large boutons and the smooth surface of the dendrites is characterized by membranous and paramembranous specializations. They are not associated with clusters of synaptic vesicles and are very similar to the filamentous contacts[3], and adhesion plaques[4] described by others. Sections tangential to the apposed membranes, and reconstructions of this interface from serial sections show that the specializations are arranged in a network, with areas of apparently unspecialized membrane apposition (about 0.2 μm across) in its interstices. It seems unlikely to us that this specialization has purely mechanical functions[4].

Participating in the VB glomeruli are also boutons containing flattened synaptic vesicles (F boutons). They establish type 2 synaptic contacts, and filamentous contacts, with the smooth surface of the glomerular dendrites where the latter are not pressed against the surface of the large bouton. Additional contacts are made with extraglomerular portions of the glomerular dendrites, and with other dendrites of unknown provenance in the extraglomerular neuropil. One of the 4 F boutons associated with the reconstructed glomerulus showed an unusual relationship to 2 of the heads of the large compound excrescence arising from D3. The 2 heads, which received excitatory synaptic contacts from the large bouton, emerged from the bouton and each received a synaptic contact from the F bouton.

The astrocytic capsule around the synaptic complex is complete except where axons and dendrites enter or leave the glomerulus. It comprises a single, relatively wide cytoplasmic sheet, or several very thin lamellae (separated by an unusually narrow extracellular space), often in the form of a series of curved, concentric lamellae, rather like a stack of delicate cups with thickened rims in which run circumferential tubules of smooth endoplasmic reticulum. The astrocyte lamellae may also invaginate the large boutons with spine-like protrusions resembling dendritic excrescences in size and internal appearance. This similarity can result in the misidentification of invaginated profiles seen in single sections[5].

The absence of synaptic contacts between the large ('specific' afferent) bouton and other neuronal processes containing synaptic vesicles is an important feature of rat VB. Axo-axonal synapses are constant features of synaptic glomeruli in the VB complex of cats[2,6], and in the lateral geniculate nucleus of primates[3,7], cats[8,9] and rats (personal observations; KARLSSON[10]), and recently dendro-dendritic synapses have also been identified in cat VB[6] and lateral geniculate nucleus[11]. The relative simplicity of the rat VB should make this nucleus a most favourable site for physiological studies of transmission through the thalamus, and for deciding upon the significance of the more complex circuitry in other sites.

Résumé. L'organisation tridimensionelle des glomérules synaptiques enveloppés dans les processus astrocytiques du thalamus somatosensoriel du rat a été étudié par microscopie électronique. Un glomérule entier a été reconstruit et divers paramètres des rapports synaptiques et non-synaptiques entre les éléments constitutifs ont été mesurés.

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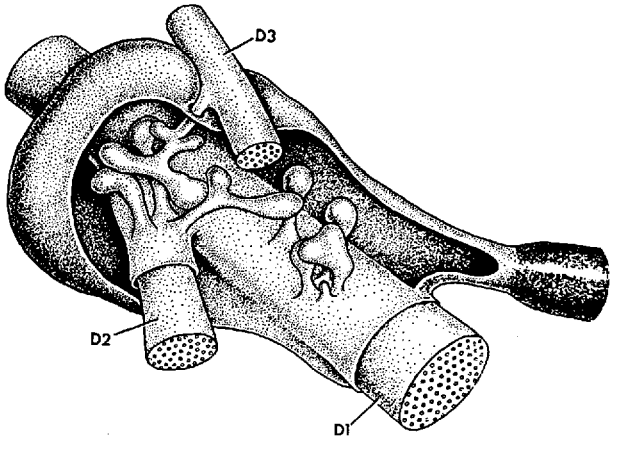

Schematic drawing based on three-dimensional reconstructions of a synaptic glomerulus in the rat ventrobasal thalamus. Relationships between the dendritic components (D1, 2, 3), the excrescences arising from them, and the large axon terminal into which the excrescences are invaginated are shown in simplified form and not strictly to scale. Synaptic vesicles, mitochondria, and other organelles in the cut-away axon terminal are not shown. Also omitted for the sake of clarity, are the F boutons and the astrocytic capsule that envelops the glomerulus.

[1] J. SZENTÁGOTHAI, in *Information Processing in the Nervous System* (Eds. R. W. GÉRARD and J. W. DUYFF, Excerpta Medica, Amsterdam 1962), vol. 3, p. 119.
[2] E. G. JONES and T. P. S. POWELL, Proc. R. Soc. B *172*, 153 (1969).
[3] M. COLONNIER and R. W. GUILLERY, Z. Zellforsch. *62*, 333 (1964). – R. W. GUILLERY and M. COLONNIER, Z. Zellforsch. *103*, 90 (1970).
[4] A. PETERS and S. L. PALAY, J. Anat., Lond. *100*, 451 (1966).
[5] J. ŠPAČEK and A. R. LIEBERMAN, Z. Zellforsch., *115*, 494 (1971).
[6] H. J. RALSTON III and M. M. HERMAN, Brain Res. *14*, 77 (1969).
[7] J. PECCI SAAVEDRA and O. L. VACCAREZZA, Brain Res. *8*, 389 (1968).
[8] J. SZENTÁGOTHAI, J. HÁMORI and T. TÖMBÖL, Expl. Brain Res. *2*, 283 (1966).
[9] R. W. GUILLERY, Z. Zellforsch. *96*, 1 (1969).
[10] U. KARLSSON, J. Ultrastruct. Res. *17*, 137 (1967).
[11] E. V. FAMIGLIETTI JR., Brain Res. *20*, 181 (1970).
[12] We thank the Wellcome Trust and British Council for support, Mrs. J. ASTAFIEV for drawing the figure, and Professors E. G. GRAY, P. D. WALL and J. Z. YOUNG for discussion.