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The Distribution of Vasopressinergic and Oxytocinergic Neurons in the CNS of the Gerbil

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Ching-Ming Wu and Ching-Liang Shen (1994) The distribution of vasopressinergic and oxytocinergic neurons in the CNS of the gerbil. *Zoological Studies* **33**(2): 114-125. This is the first immunohistochemical report on the distribution of the vasopressin (VP) and oxytocin (OT) producing neurons and their processes in the central nervous system of the gerbil. These neurons are primarily associated with the paraventricular, supraoptic and accessory neurosecretory nuclei. Two types of immunoreacted neurons, large multipolar (magnocellular) and small fusiform (parvocellular), coexist in some of these nuclei. The distribution of VP neurons is broader than that of OT neurons. Only VP neurons are observed in the suprachiasmatic nucleus, internal capsule, medial amygdala, dorsal hypothalamic area, dorsomedial nucleus, lateral hypothalamic area and dorsal capsule of the ventromedial nucleus within the hypothalamus. VP neurons in these nuclei where OT neurons do not coexist are all parvocellular type. By contrast, only OT neurons were detected in the medial preoptic area. VP and OT containing fibers were observed throughout the central nervous system of the gerbil. Most of the projections of these two neuropeptidergic fibers terminate in the neurohypophysis and median eminence. Extrahypophyseal projections have also been observed. The distribution of VP neurons and their fibers are more extensive in the gerbil than in other mammals. VP neurons distributed within the internal capsule, dorsal hypothalamic area and dorsal capsule of the ventromedial nucleus of the gerbil have not yet been described in other mammals. Moreover, the diffuse VP fiber distribution in the mammillary body of the gerbil is seldom observed in that of other mammals. Due to the antidiuretic role of VP, the well-developed VP system of the gerbil may be reflected by its excellent water reservation ability.

Key words: Immunohistochemistry, Vasopressin, Oxytocin.

The hypothalamic vasopressin (VP) and oxytocin (OT) neurons are well known for their respective neurohypophyseal hormone secretions, vasopressin and oxytocin. Many scholars have described the peripheral endocrine effects of VP and OT. VP affects antidiuresis regulation (Emmers 1973) and blood pressure (Sawyer 1971). OT effects uterine smooth muscle contraction during labor (Cross 1958, Munsick 1960) and mammary gland conntraction during milk ejection (Peeters et al. 1960). In addition, increasing evidence confirms their neurotropic effects in liver metabolism (Martin and Baverek 1981), cardiovascular regulation (Mohring et al. 1981), thermoregulation (Cooper et al. 1979) and pain modulation (De Wied 1983). Other behavior, such as avoidance, reward, memory and maternal behavior are influenced by both neuropeptides (Van Wimersma Greidanus 1982).

The organization of the hypothalamo-hypophyseal system in many species has been studied with various methologies (Scharrer and Scharrer 1954, Bargmann and Scharrer 1954, Dawson 1953, Peterson 1966). Technical limitations prevented earlier studies from revealing projecting fibers from this system clearly. Currently immunohistochemical techniques ease the identification of neuropeptide containing neurons as well as their neural pathways and targets. Immunohistochemical techniques have confirmed that VP and OT are produced by large perikarya of the supraoptic nucleus and several accessory neurosecretory nuclei as well as by large and small perikarya of the paraventricular nucleus. The hypothalamo-hypophyseal system has been described by using these techniques in the rat (Vandesande and

Dierickx 1975, Sokol et al. 1976), guinea pig (Sofroniew et al. 1979, Dubois-Dauphin et al. 1989a, b), cat (Reaves and Hayward 1979, Caverson et al. 1987), cow (Vandesande et al. 1975), horse (Melrose and Knigge 1989), pig (Van Eerdenburg et al. 1992), monkey (Zimmerman et al. 1977, Caffe et al. 1989), human (Dierickx and Vandesande 1977, Ulfig et al. 1990), and some nonmammalian vertebrates (Berk et al. 1982, Goossens et al. 1977). Among these, the system of the rat has been studied most pervasively.

In our study, we investigated the gerbil posession of a well-developed hypothalamo-hypophyseal system in order to explain its extraordinary water reservation ability. Besides, gerbil system data are unavailable; results of our study may be valuable in comparative studies of the hypothalomo-hypophyseal system in mammals.

MATERIAL AND METHODS

Six male Mongolian gerbils were used to study the central nervous system distribution of vasopressin and oxytocin immunoreactive cell bodies and fibers. We applied the indirect peroxidase-antiperoxidase (PAP) technique (Sternberger et al. 1970) in this study. Brief procedures are as follows:

The animals were anesthetized with Nembutal (35 mg/kg, I.P.) and fixed by intracardiac perfusion with a 4% peroxidate-lysine-paraformaldehyde (PLP) fixative. After removal and PLP postfixation (2 hrs) the brains and spinal cords were washed thoroughly with a 0.1M phosphate buffer (PB, pH 7.2) solution. Prior to sectioning, the brains and spinal cords were cryoprotected in 10% and 20% sucrose solutions each for a period of 2 hours, and then in a 30% sucrose solution in 0.1M PB overnight. Using a freezing microtome serial coronal sections of 40 μm were collected and stored in six vials. Sections were then incubated at 4°C for 48 hours in primary antibody solutions: anti-rabbit vasopressin (vials 1, 3 and 5) or oxytocin (vials 2, 4, and 6) antisera (these antisera were pretreated by diluting antibody 1:1000 with 200 μg of antisera and a 0.1M PB containing 0.3% Triton X-100 and 1.0% normal goat serum). After standing at room temperature for 30 minutes and a 0.1M PB rinse, sections were then incubated in goat-antirabbit-IgG secondary antibody solution (1:100) for 30 minutes, rinsed with 0.1M PB and exposed to rabbit peroxidase-antiperoxidase antibody (1:100) for 45 minutes. Sections were again washed with a 0.1M PB. The incubated sections were then placed in a freshly prepared 0.05% diaminobenzidine (DAB) solution. A 0.3% hydrogen peroxide solution was added and the reaction was monitored under a low-power microscope for 20 minutes. Following the reaction stage, the sections were mounted on subbed slides, intensified with 0.1% osmic acid, dehydrated with ethanol, and cover-slipped with permount; they were then examined and under a light microscope a cell count was taken. All positive profiles with a soma were counted as a neuron. According to the specification sheet given supplied by Immuno Nuclear, all staining is blocked with absorption control for arginine and lysine indicative of VP and OT, respectively. Antisera specificities for VP (Lot No. V-5501, Sigma) and OT (Lot No. V-1627, Sigma) were further proven by preabsorption by some sections of a VP and OT antigen antisera (10 μl concentration). No positive immunoreactivity was detected in these sections.

RESULTS

VP and OT antisera reacted neurons were brown or brownish and their processes were brown with beaded varicosities. Both neuropeptidergic neurons spreaded from the ventral of the forebrain (Fig. 1) to the diencephalon. Most VP neuron containing nuclei or areas also had OT neurons; they

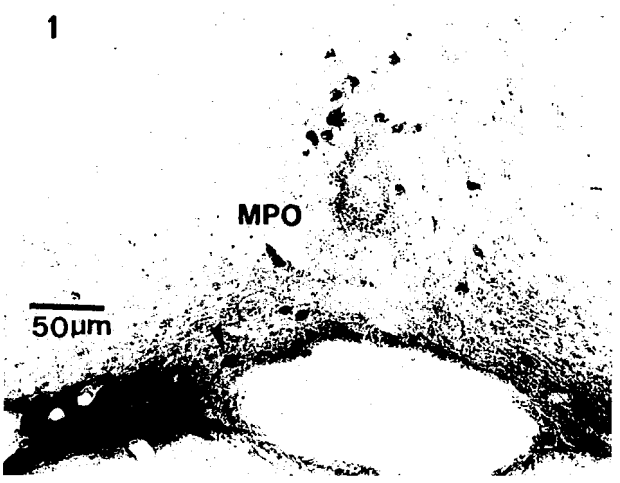


Fig. 1. This is the most rostral level just before the anterior commissure (ac) where OT immunoreactivities begin to be found. Photomicrograph displays OT immunoreactive cell bodies in the medial preoptic nucleus (MPO) and on the ventral of the forebrain (arrow).

were concentrated mainly in the supraoptic nucleus, paraventricular nucleus and accessory neurosecretory nuclei of the hypothalamus (Fig. 2). Some neuron reaction in the bed nucleus of stria terminalis and periventricular zone was also noted. Two immunoreacted neuron types: large multipolar (magnocellular type, size 25-35 μm) and small fusiform (parvocellular type, size 12-20 μm), were observed. Some differences existed between the distribution patterns of immunoreactivities of both neuropeptides. The distribution of VP neurons was wider than that of OT neurons. VP neurons were observed in the suprachiasmatic nucleus, medial amygdala, dorsomedial nucleus, dorsal capsule of the ventromedial nucleus, dorsal and lateral hypothalamic area; while only OT neurons were detected in the medial preoptic area. The number and cell types of VP and OT neurons were enumerated in Table 1.

Both neuropeptidergic fibers and their respective terminals coexisted throughout the neuroaxes, but immunostaining density varied. Obviously, the majority of these fibers stemmed from the paraventricular nucleus and supraoptic nucleus towards the neurohypophysis and the median eminence portal capillary system (Figs. 3a, b). A few of the reacted fibers reach other neural and neurohemal targets. These VP and OT fiber targets were listed in Table 2. The disposition of both neuropeptidergic immunoreactivities were described below.

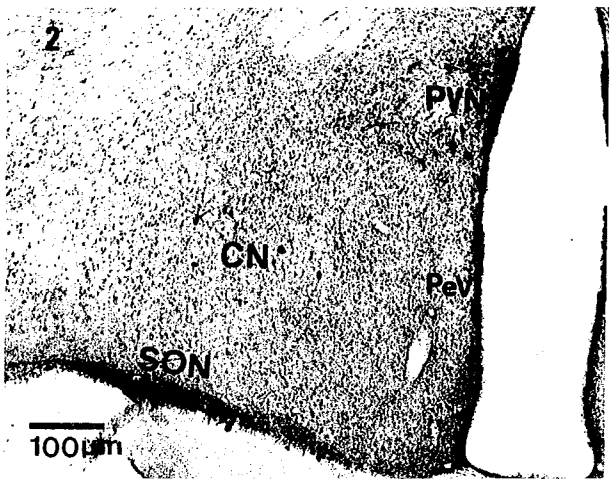


Fig. 2. A section just behind the anterior commissure. VP cell bodies appear on the wall of the periventricular zone of the 3rd ventricle. Note the sparsity of reacted neurons of the paraventricular nucleus (PVN).

Immunoreacted perikarya

Paraventricular nucleus

This nucleus contained many VP and OT neurons which were located in the medial, lateral and posterior areas. The reacted neurons in the medial and lateral parts of the paraventricular nucleus were closely packed together in a quasi conic formation. Although these two areas contained both large and small VP cell bodies, the medial part primarily consisted of small neurons, the lateral part contained a core of large ones. Posterior region VP neurons alligned themselves in a mediolateral direction to the fornical nucleus. VP cell bodies were more caudally and ventrally concentrated in the paraventricular nucleus, while OT neurons were more rostrally and dorsally located.

Supraoptic nucleus

This nucleus included only large reacted neurons in its principal and retrochiasmatic parts. The principal part contained most of the reacted neurons. Like the distribution within the paraventricular nucleus, VP neuron arrangement was largely caudal and ventral, while OT neurons were mainly rostral and dorsal.

Table 1. The Distribution and Neuronal Number of Magnocellular (m) and Parvocellular (p) Containing Neurohypophyseal Peptidernergic Neurons in the Brain of the Gerbil

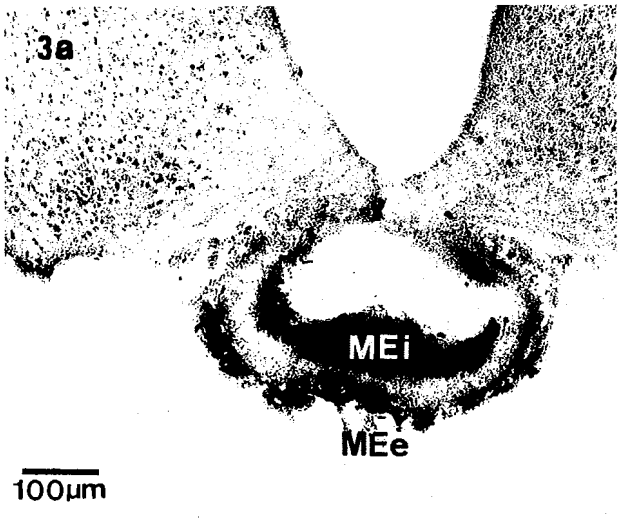
	VP	OT
Telencephalon		
Bed nucleus of stria terminalis	42, m	16, m
Amygdala	12, p	—
Medial preoptic nucleus	—	78, m
Internal capsule	158, p	—
Diencephalon		
Suprachiasmatic nucleus	162, p	—
Paraventricular nucleus	2952, m, p	1540, m, p
Supraoptic nucleus	3288, m	2018, m
Accessory neurosecretory nuclei		
Fornical nucleus	414, m	230, m
Circular nucleus	152, m	74, m
Nucleus of medial forebrain bundle	198, m	84, m
Dorsal hypothalamic area	142, p	—
Ventromedial nucleus	84, p	—
Dorsomedial nucleus	182, p	—
Lateral hypothalamic area	378, p	—
Total	8164	4040

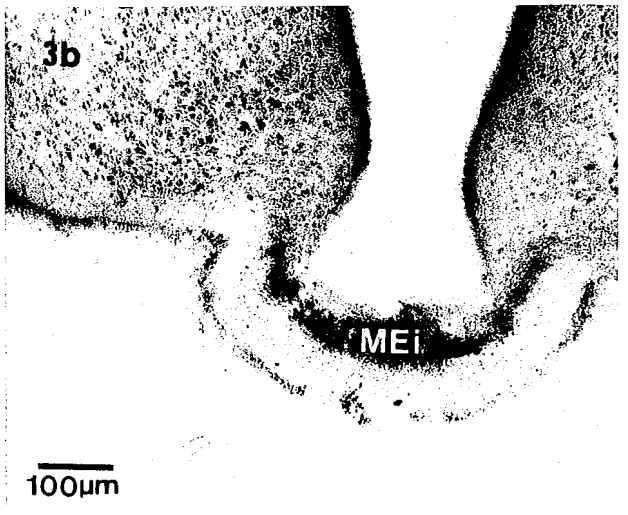
Accessory neurosecretory nuclei

Only large VP and OT neurons were observed in the accessory neurosecretory nuclei. These were the fornical, circular (Fig. 2) and median forebrain bundle nuclei (Figs. 5, 6, 7). Among them, the fornical nucleus included the most numerous reacted neurons. A few VP neurons and fibers ran from the posterior part of the paraventricular nucleus to the fornical nucleus and intertwined with reacted neurons of the latter (Figs. 5a, b). The circular nucleus was a small nucleus with some reacted neurons; blood vessels surrounded by these neurons within this nucleus were observed occasionally. The VP and OT neurons within the nucleus of medial forebrain bundle were diffusely distributed in the internuclear zone and always paralleled the fibers of the paraventriculo-supraoptico-neurohypophyseal tract.

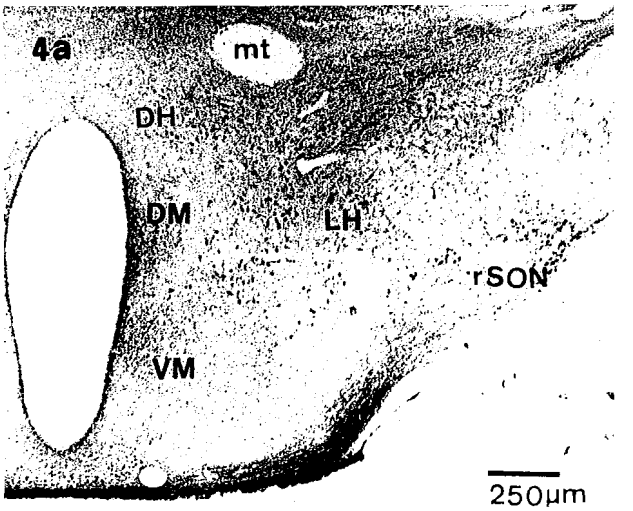
Suprachiasmatic nucleus

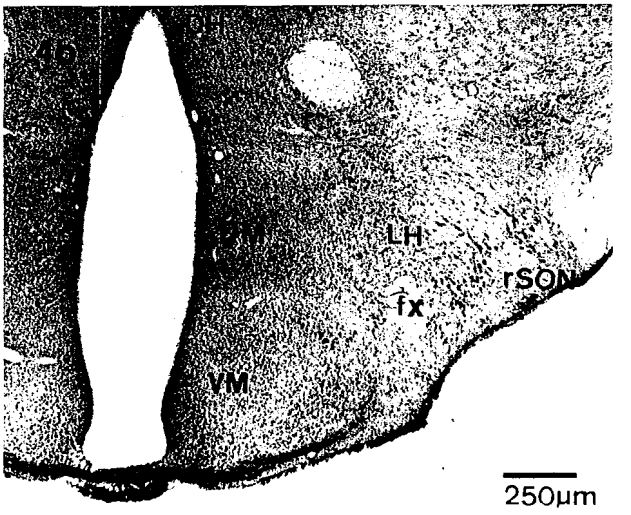
A few small VP neurons appeared in the dorsomedial part of this nucleus (Figs. 6a, 7a). No





Figs. 3a-b. Photomicrographs reveal VP and OT containing fibers projecting to the portal capillaries of the median eminence (ME). In Fig. 3a, dense VP fibers terminate in the internal and external layers of the ME. While in Fig. 3b, OT fibers are only observed in the internal layer of the ME.



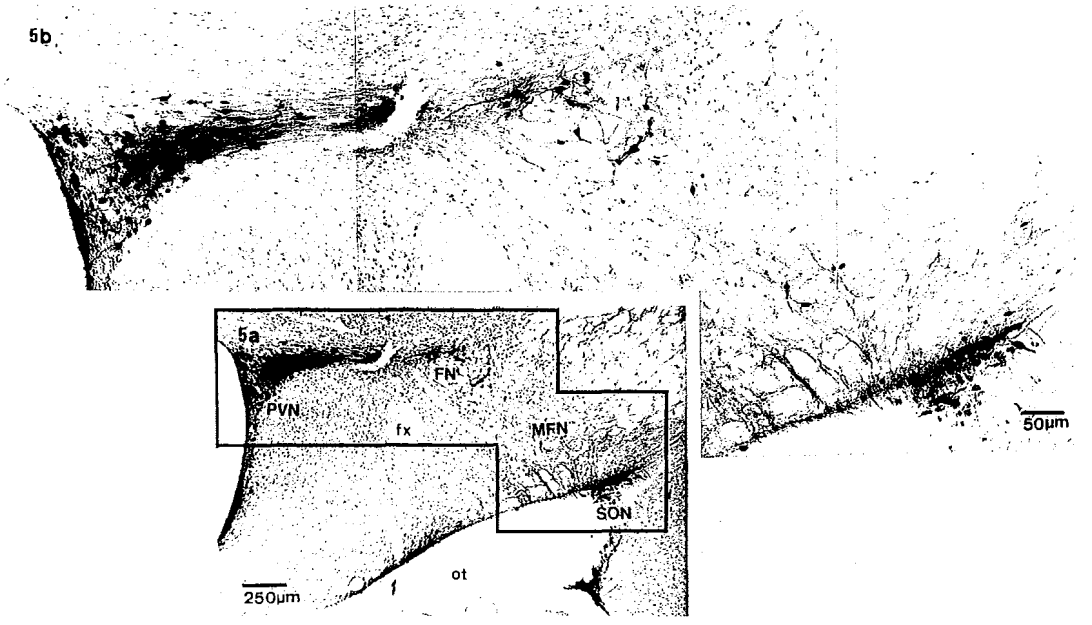


Figs. 4a-b. Fig. 4a shows several VP neurons in the dorsal hypothalamic area (DH), ventromedial nucleus (VM) and the dorsomedial nucleus (DM) intermingle in the lateral hypothalamic area (LH). No OT cell bodies are found at or behind this level. Fig. 4b is more caudal than 4a. Note VP neurons assemble in the dorsal capsule of the VM.

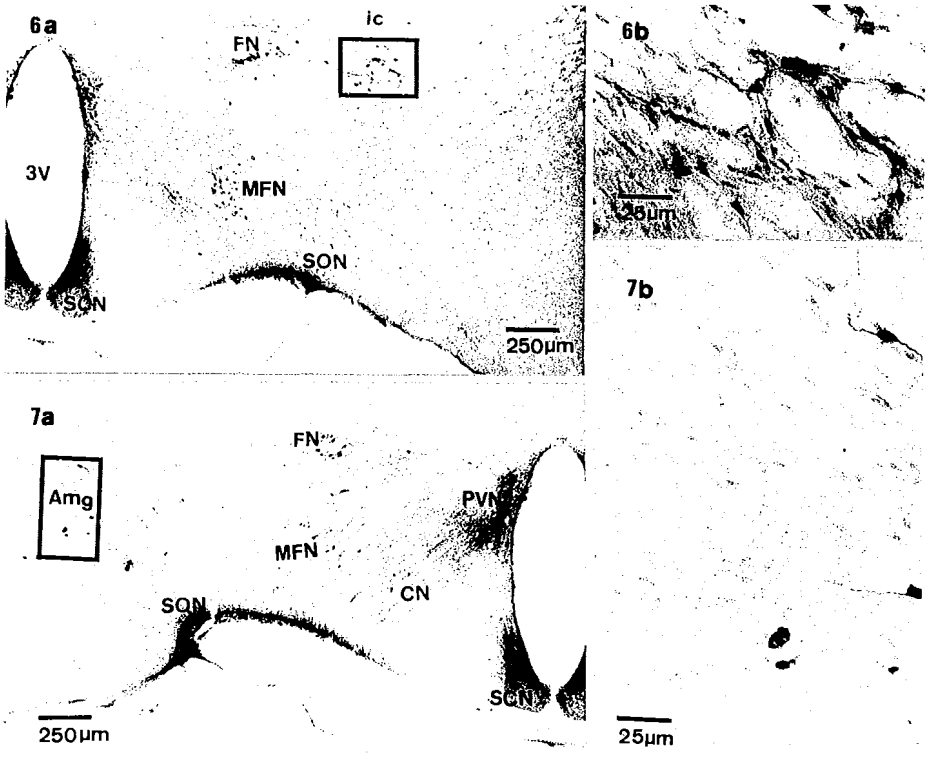
Table 2. The Density of Vasopressin (VP) and Oxytocin (OT) Nerve Fibers in the CNS of the Gerbil

	VP	OT
Telencephalon		
Frontal cortex	(+)	(+)
Diagonal tract of Broca	+ + +	(+)
Accumbens nucleus	+	+
Lateral septum	+ +	(+)
Medial septum	+	(+)
Medial amygdala	+	(+)
Bed nucleus of stria terminalis	+ +	+
Hippocampus	+	+
Subfornical organ	(+)	(+)
Diencephalon		
Neural lobe	+ + + + +	+ + + + +
Median eminence		
internal zone	+ + + + +	+ + + + +
external zone	+ + + +	
Organum vasculosum laminae terminalis	+ + +	
Lateral habenular nucleus	+ +	(+)
Mediodorsal thalamus	+ +	(+)
Periventricular zone	+ +	(+)
Dorsomedial nucleus	+ +	+
Posterior nucleus	+ +	(+)
Supramammillary nucleus	+ +	+
Mammillary body	+	
Mesencephlon		
Substantia nigra	+	+
Dorsal raphe nucleus	+ +	+ +
Ventral tegmental area	+	+
Interpeduncular nucleus	+	+
Subcommissural organ	(+)	(+)
Rhombencephalon		
Area postrema	(+)	(+)
Periventricular gray	+	+
Parabrachial nucleus	+ +	+ +
Locus coeruleus	+	+
Raphe pontis nucleus	+	+
Nucleus solitarius/vagus complex	+ +	+ +
Commissural nucleus	+	+
Lateralis reticularis nucleus	+	+
Raphe magnus nucleus	+ +	+ +
Raphe obscurus nucleus	+	+
Nucleus of spinotrigeminal tract	+	+
Spinal cord		
Dorsal horn	(+)	(+)
Central gray	(+)	+
Lateral horn	(+)	(+)

"+" indicate positive reacted fibers: (+) observed sometimes; + very low density; + + low density; + + + moderate density; + + + + high density; + + + + + very high density.



Figs. 5a-b. Fig. 5a shows the relation of four VP containing nuclei in the hypothalamus. Fig. 5b is an enlarged photomicrograph with details displayed in Fig. 5a. In Fig. 5b, numerous immunoreacted cell bodies are aggregated within the paraventricular nucleus, supraoptic nucleus and fornical nucleus (FN), and is scant in the nucleus of medial forebrain bundle (MFN). Obviously, the immunoreacted cells of the paraventricular nucleus ventrolaterally extend their long processes out toward the supraoptic nucleus and fornical nucleus. Note the immunoreacted cell processes adjacent to the border of the optic tract (ot) and ventral surface of the forebrain.



Figs. 6a-b. Fig. 6a shows VP immunoreactivities in the anterior hypothalamus. Note some VP neurons diffuse in the inferior part of the internal capsule. Fig. 6b is enlarged from the rectangle of Fig. 6a.

Figs. 7a-b. Fig. 7a shows VP immunoreactivities in the amygdala. Fig. 7b is enlarged from the rectangle of the Fig. 7a.

OT neuron was observed there.

Bed nucleus of stria terminalis

Small VP and OT neurons scattered around the anterior commissure; Some oriented in the direction of the stria terminalis.

Other parts of the brain

In addition to the distribution of reacted neurons described above, a number of VP and OT neurons appeared in the rostral forebrain and caudal diencephalon. At the most rostral part, both VP and OT neurons were found in the rostral periventricular zone, but only large OT neurons were detected in the medial preoptic nucleus (Fig. 1). At the caudal diencephalon, numerous small pure VP neurons were encountered in the dorsal hypothalamic area, dorsomedial nucleus, lateral hypothalamic area and dorsal capsule of ventromedial nucleus (Figs. 4a, b). There were 786 out of a total 8164 VP neurons in these nuclei (Table 1). Moreover, some VP neurons were sparsely distributed in the inferior part of the internal capsule (Fig. 6b) and in the medial amygdala (Fig. 7b).

Immunoreacted fibers

Almost all VP and OT fibers projected to the same fields. OT fiber density was much less in the forebrain, particularly in the limbic system. In the brainstem, OT fibers as well as VP fibers were moderately distributed within the dorsal raphe nucleus, raphe magnus nucleus and nucleus solitarius/vagus complex. Further, VP fibers dispersed in both internal and external zones of the median eminence, while OT fibers were only observed in the internal zone of the median eminence (Figs. 5a, b). Only VP fibers could be found in the organum vasculosum laminae terminalis.

Telencephalon

OT fibers were slightly dispersed, while various densities of VP fibers were found in most areas of the telencephalon. Moderately VP labeled fibers were observed in the diagonal band of Broca (Fig. 8). VP fiber density was low in the lateral septum (Fig. 9) and bed nucleus of striae terminalis. The accumbens nucleus, medial septum, medial amyg-

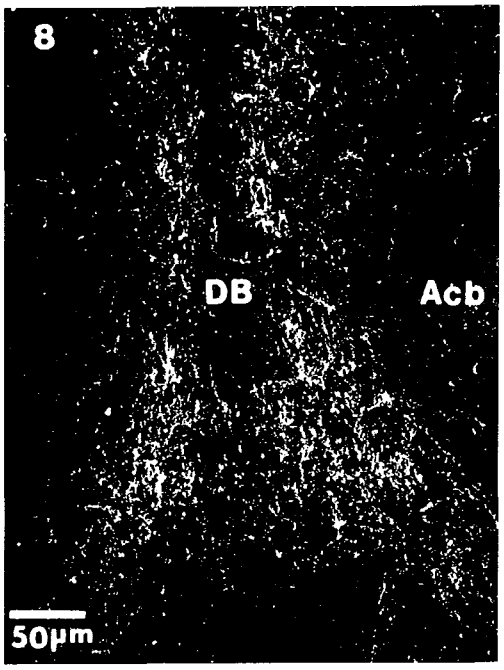


Fig. 8. Dark field photomicrographs show no immunoreacted neurons but dense and conspicuous fibers in the diagonal bank of Broca.

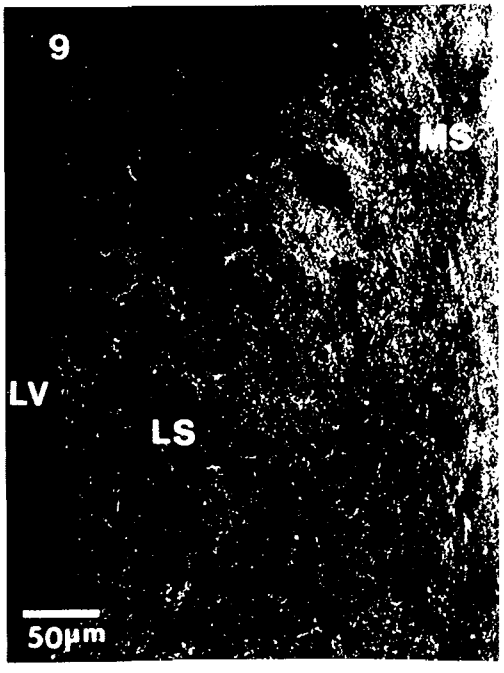


Fig. 9. Dark field photomicrographs show no immunoreacted neurons but dense and conspicuous fibers in the lateral septum.

dala and hippocampus were labeled with a very low VP fiber density. Only few VP fibers were found in the cerebral cortex and subfornical organ.

Diencephalon

This part had much more VP and OT fibers than other parts of the central nervous system. Distinctively, the highest reacted fiber density was in the neural lobe and median eminence. Lowly labeled fibers were found in the lateral habenular nucleus, mediodorsal thalamus (Fig. 11), periventricular zone, dorsomedial nucleus, posterior nucleus, suprachiasmatic nucleus (Figs. 6a, 7a) and supramammillary nucleus. A very low density of reacted fibers distributed in the ventral and lateral of the mammillary body (Fig. 10).

Mesencephalon

Excluding lowly labeled VP and OT fibers in the dorsal raphe nucleus, reacted fibers scantly terminated in the central gray, substantia nigra, ventral tegmental area and interpeduncular nucleus. Reacted fibers in the subcommissural organ were observed occasionally.

Rhombencephalon and spinal cord

Both VP and OT fibers were sparsely distributed in the parabrachial nucleus, raphe magnus (Fig. 12), nucleus solitarius/vagus complex (Fig. 11). In the locus coeruleus, raphe pontis nucleus, lateral reticular nucleus, raphe obscurus nucleus and nucleus of spinotrigeminal tract, a very low reacted fiber density was observed. Slightly reacted fibers were observed in the area postrema, and the dorsal horn, central gray and lateral horn of the spinal cord.

DISCUSSION

This is the first paper to describe the distribution of vasopressin and oxytocin neurons in the CNS of the Mongolian gerbil. Both neuropeptidenergic neuron arrangement patterns of the gerbil are similar to those of other mammals (Silverman and Zimmerman 1983). Both VP and OT neurons are mainly associated with the paraventricular nucleus, supraoptic nucleus and accessory nuclei of the gerbil. The arrangement of both neuropeptidergic neurons within the paraventricular nucleus and supraoptic nucleus have spatial differences; VP neurons are situated more caudally and ventrally, while OT neurons are located more rostrally and dorsally. However, the distribution of these neurons in other nuclei is different between the gerbil and other mammals (Silverman and Zimmerman 1983). Numerous VP neurons occur in the internal capsule and in the nuclei of the caudal diencephalon, including the dorsal hypothalamic area, dorsomedial nucleus, lateral hypothalamic area and the dorsal capsule of the ventromedial nucleus of the gerbil, but not in those of other species. For example, only the lateral hypothalamic nucleus of the cat (Reaves and Hayward 1979) and the dorsomedial nucleus of the rat (Caffe and Van Leeuwen 1983) have been reported to contain

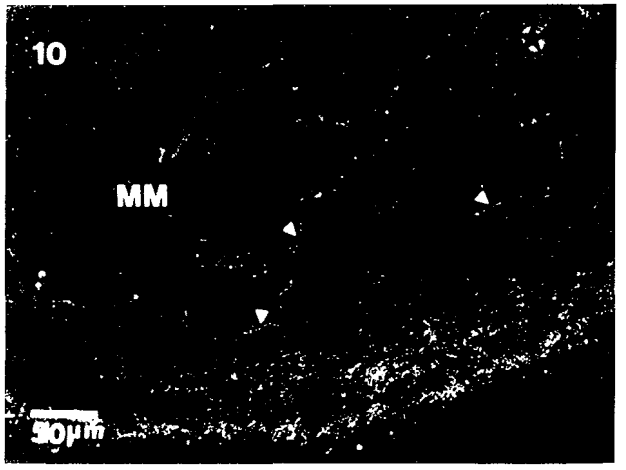


Fig. 10. Dark field photomicrographs show no immunoreacted neurons but dense and conspicuous fibers in the mammillary body.

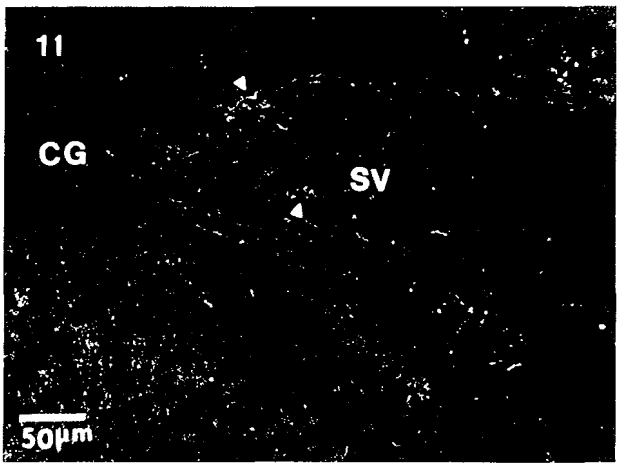


Fig. 11. Dark field photomicrographs show no immunoreacted neurons but dense and conspicuous fibers in the solitarius/vagus complex.

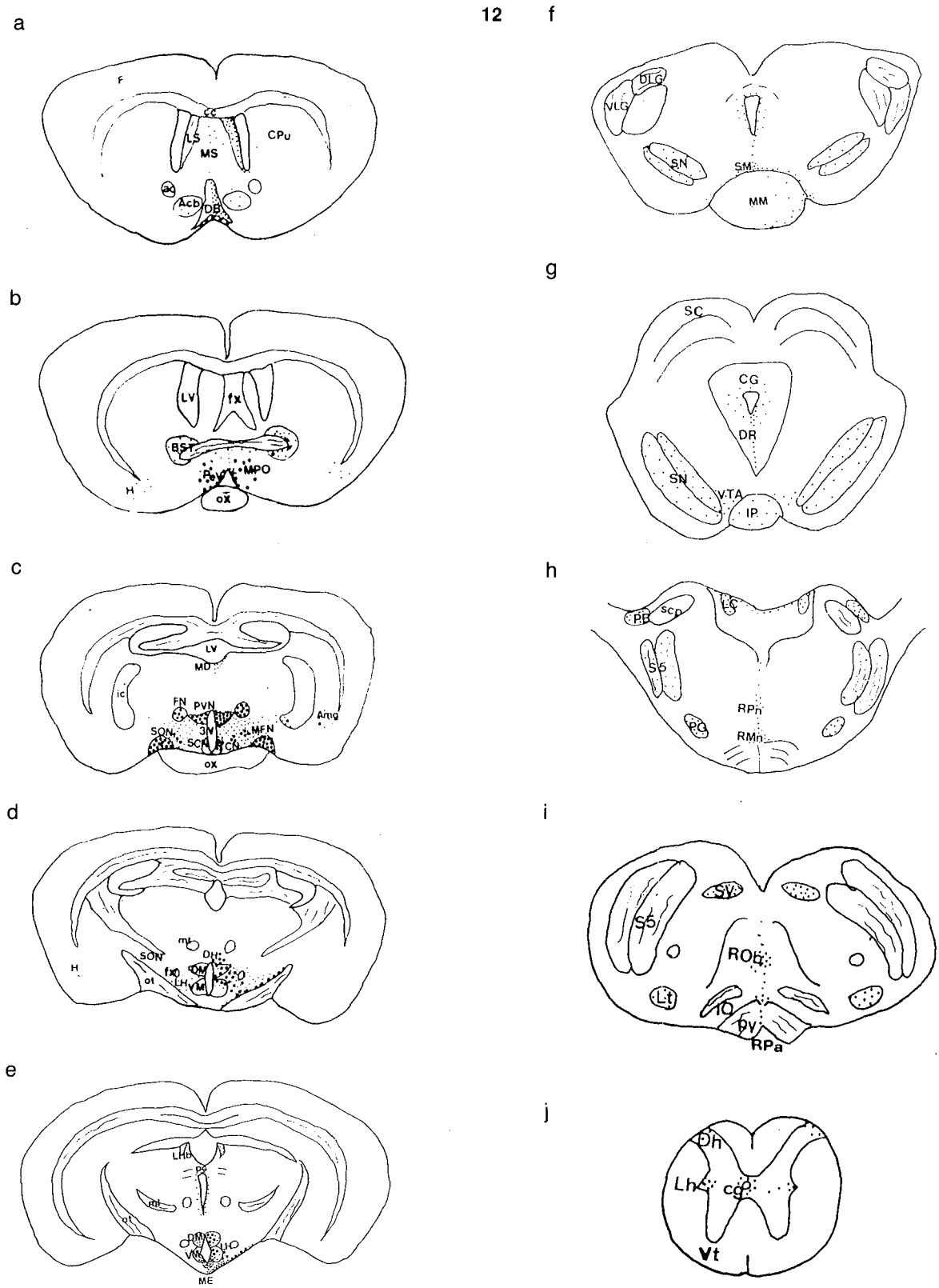


Fig. 12. Schematic drawings show the distribution of VP immunostaining neurons (large dots) and fibers (small dots) from the forebrain to the spinal cord of the gerbil. OT neurons only distribute before level e and no VP neurons are found under caudal diencephalon (level f). The thoracic level of the spinal cord is presented in j.

VP neurons. Similarly, a group of OT neurons in the gerbil medial preoptic area have been described only in those of the pig (Van Eedenburg 1992), horse (Melrose and Knigge 1989) and guinea pig (Dubois-Dauphin 1989a, b). VP and OT neurons have not been found in the diagonal band of Broca of the gerbil, guinea pig (Dubois-Dauphin 1989a, b) and pig (Van Eerdenburg 1992). Such results contrast with reports of VP neurons in the diagonal band of Broca of the rat (Sofroniew 1985), cat (Caverson et al. 1987), monkey (Caffe et al. 1989) and man (Ulfig et al. 1990), as well as with a report of OT neurons in the diagonal tract of Broca of the cat (Caverson et al. 1987). That VP neurons located in the locus coeruleus of the rat (Caffe and Van Leeuwen 1983) is also not found in the gerbil and other species (Silverman and Zimmerman 1983).

VP and OT containing fibers and terminals with various densities are located throughout the gerbil CNS. The majority VP and OT fibers stem from the paraventricular nucleus and supraoptic nucleus and project to the neurohypophysis and median eminence. In the gerbil forebrain, VP fibers are higher in density than OT fibers, especially in the limbic system including: the lateral septum, lateral habenular nuclei, amygdala, mammillary body and some hypothalamic nuclei. While the densities of both VP and OT fibers are light in the most areas of the brainstem and spinal cord of the gerbil. Comparing the gerbil to other mammals (Swanson and Kuypers 1980, De Vires and Buijs 1983), various data on both reacted fibers exists. Among these VP projection targets, reports regarding the mammillary body are scant and have only been revealed by anterograde autoradiographic tracing method (Alonso et al. 1984).

The roles of VP and OT as hormones, when transported to vascular targets, have been confirmed by many investigators (Gash and Boer 1987). Other reports concerning their extrahypophyseal projections as neurotransmitters, when transported to the effector neurons in axons, are abundant (Cooper et al. 1979, De Wied 1983, Van Wimersma Greidanus 1982). The VP neurons spreading in the lateral hypothalamic area and VP fibers difusing in the subfornical organ are deeply thought to involve in drinking behavior and body water balance (Emmers 1973, Milton and Paterson 1974, Miselis 1982). Dominant distribution of VP neurons in the lateral hypothalamic area and sparse disposition of VP fibers in the subfornical organ might explain the excellent drought-resisting ability of the gerbil. VP and OT fibers, related with the limbic system, imply a wide variety of behavioral effects on the gerbil and other species (De Wied 1977, De Wied and Versteeg 1979).

Although VP and OT fibers are sparse in the most areas of the gerbil brainstem and spinal cord, medium densities of both reacted fibers in some brainstem regions of the gerbil have been encountered, such as the dorsal raphe nucleus, nucleus vagus/solitarius complex and parabrachial nucleus. Additionally, VP and OT projections located in the autonomic centers of the brainstem including the locus coeruleus, parabrachial nucleus, nucleus tractus solitarius, dorsal motor nucleus of vagus and the lateral horn of the spinal cord. They are thought to participate in the processes of autonomic regulation (Swanson 1977). The nucleus solitarius, involved in cardiovascular regulation, has been shown to receive VP fibers from the suprachiasmatic nucleus and paraventricular nucleus (Swanson 1977, Sofroniew and Weidl 1978b). Our observations also concur with their views.

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ABBREVIATIONS

3V	Third ventricle
ac	Anterior commissure
Acb	Accumbens nucleus
Amg	Amygdala
BST	Bed nucleus of stria terminalis
cc	Corpus callosum
CN	Circular nucleus

CG Central gray (cg: lamina X)
CPu Caudate putamen
DB Diagonal tract of Broca
DLG Dorsal lateral geniculate nucleus
Dh Dorsal horn (lamina I-III)
DH Dorsal hypothalamic area
DM Dorsomedial nucleus
DR Dorsal raphe nucleus
F Frontal cortex
FN Fornical nucleus
fx Fornix
H Hippocampus
ic Internal capsule
IPN Interpeduncular nucleus
IO Inferior olivary
LC Locus coeruleus
LHb Lateral habenula
Lh Lateral horn
LS Lateral septum
Lt Lateralis reticularis nucleus
LV Lateral ventricle
MD Mediodorsal thalamus
MEe Median eminence (external zone)
MEi Median eminence(internal zone)
MFN Nucleus of medial forebrain bundle
MM Mamillary body
MPO Medial preoptic nucleus
MS Medial septum
mt Mammillothalamic tract
ot Optic tract
ox Optic chiasm
PB Parabrachial nucleus
pc Posterior commissure
PeV Periventricular zone
PG Paragigantoreticular nucleus
PVN Paraventricular nucleus
py Pyramidal tract
RMn Raphe magnus nucleus
ROb Raphe obscurus nucleus
RPa Raphe pallidus nucleus
RPn Raphe pontis nucleus
S5 Nucleus of spinotrigeminal tract
SC Superior colliculus
scp Superior cerebellar peduncle
SM Supramammillary nucleus
SN Substantia nigra
SON Supraoptic nucleus
ST Stria terminalis
SV Solitarius/vagus complex
Vh Ventral horn
VLG Ventral lateral geniculate nucleus
VM Ventromedial nucleus
VTA Ventral tegmental area

含血管加壓素及催產素的神經元在沙鼠之中樞神經系統的分佈

吳慶明　沈清良

本實驗是首次以免疫組織化學法來探討含血管加壓素(vasopressin, VP)及催產素(oxytocin, OT)的神經元和其突起在蒙古種沙鼠中樞神經系統中的分佈情形。結果顯示這兩類神經元主要分佈於腦室旁核、視徑上核以及一些附屬神經分泌核中。這些神經元可分爲大型多角形和小型梭形兩類，且共存於一些神經核中。含血管加壓素的神經元比含催產素的神經元分佈廣；在視交叉上核、內側杏仁核、下視丘的背側下視丘區、背內側核、外側下視丘區、腹內側核的背側中，只有含血管加壓素的神經元，且這些皆爲小型神經元。相反的，在內側視丘前區則僅有含催產素的神經元。含血管加壓素和含催產素的神經纖維，廣汎的分佈於沙鼠的中樞神經系統中。這些纖維大部分投射到腦下垂體和正中隆突，另有一些則屬下視丘外的投射。沙鼠含血管加壓素的神經元及其纖維的分佈比其它哺乳類的來得廣，如在內囊、背側下視丘區及腹內側核的背側等，均有含血管加壓素的神經元存在，而這些區域在其它的動物，尚未有含血管加壓素神經元的發現。而沙鼠含血管加壓素的神經纖維，投射至乳頭體的情形，在其它哺乳類動物的腦中相當少見。基於血管加壓素在抗利尿功能上的角色，沙鼠如此發達的血管加壓素系統，可能足以反映其卓越的耐渴能力。

關鍵詞：免疫組織化學法，血管加壓素，催產素。