Fowler, C. J., Callingham, B. A. (1978) Biochem. Pharmacol. 27: 907–911

Fuentes, J. A., Trepel, J. B., Neff, N. H. (1977) Exp. Geront. 12: 113–115

Garrick, N. A., Murphy, D. L. (1982) Ibid. 31: 4061–4066

Gottfries, C. G., Oreland, L., Wiberg, A., Winblad, B. (1975) J. Neurochem. 25: 667–673

Guffroy, C., Strolin Benedetti, M. (1984) Life Sci. 34: 535–545

Hollander, M., Wolfe, D. A. (1973) in: Non parametric statistical methods. Wiley, Chichester, pp. 68–75

Houslay, M. D., Marchmont, R. J. (1980) J. Pharm. Pharmacol. 32: 65–66

Huang, R. H., Faulkner, R. (1980) Mol. Pharmacol. 18: 267–273

Johnston, J. P. (1968) Biochem. Pharmacol. 17: 1285–1297

Knoll, J., Magyar, K. (1972) Adv. Biochem. Psychopharmacol. 5: 393–408

Lewinsohn, R., Böhm, K. H., Glover, V., Sandler, M. (1978) Biochem. Pharmacol. 27: 1857–1863

Lewinsohn, R., Glover, V., Sandler, M. (1980) Ibid. 29: 1221–1230

Lowe, M. C., Reichenbach, D. D., Horita, A. (1975) J. Pharmacol. Exp. Ther. 194: 522–536

Lowry, O. H., Rosenbrough, N. J., Parr, A. L., Randall, R. J. (1951) J. Biol. Chem. 193: 265–275

Lyles, G. A., Callingham, B. A. (1975) J. Pharm. Pharmacol. 27: 682–691

Lyles, G. A., Callingham, B. A. (1982a) Biochem. Pharmacol. 31: 1417–1424

Lyles, G. A., Callingham, B. A. (1982b) J. Pharm. Pharmacol. 34: 139–140

Nohl, H., Krämer, R. (1980) Mech. Ageing Dev. 14: 137–144

Oreland, L., Fowler, C. J. (1979) in: Singer, T. P., von Korff, R. W., Murphy, D. L. (eds) Monoamine oxidase: structure, function and altered functions. Academic Press, New York, pp 389–396

Robinson, D. S., Davis, J. M., Nies, A., Colburn, R. W., Davis, J. N., Bourne, H. R., Bunney, W. E., Shaw, D. M., Coppen, A. J. (1972) Lancet, 1: 290–291

Shih, J. C. (1979) in: Singer, T. P., von Korff, R. W., Murphy, D. L. (eds) Monoamine oxidase: structure, function and altered functions. Academic Press, New York, pp 413–422

Strolin Benedetti, M., Keane, P. E. (1980) J. Neurochem. 35: 1026–1032

Strolin Benedetti, M., Boucher, T., Fowler, C. J. (1983) Naunyn Schmiedeberg's Arch. Pharmacol. 323: 315–320

Tipton, K. F., Fowler, C. J., McCrodden, J. M., Strolin Benedetti, M. (1983) Biochem. J. 209: 235–242

Tipton, K. F., Houslay, M. D., Garrett, N. J. (1973) Nature New Biol. 246: 213–214

Wibo, M., Dvong, A. T., Godfraind, T. (1980) Eur. J. Biochem. 112: 87–94

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Age-related changes in the activities of the amine metabolizing enzymes of rat eye

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Eye MAO-A, MAO-B, semicarbazide-sensitive amine oxidase (SSAO) and aldehyde reductase (AR) activities were measured in young and old rats. When enzyme activity is expressed as nmol (mg protein)$^{-1}$ min^{-1}, a significant decrease (18–23%) of SSAO activity in the eye of old rats was found, whereas there was no significant difference in MAO-A and MAO-B activities. A significant increase of AR activity with D-xylose (67%), DL-glyceraldehyde (64%), D-glucuronate (43%) and D-glucose (21%) was found in the eye of old rats. These results suggest that changes in the activities of the amine metabolizing enzymes of rat eye with age might have consequences for their function in senescence; particularly, the increase of AR activity might be involved in cataract formation.

Monoamine oxidase (MAO, EC 1.4.3.4) is a mitochondrial enzyme which exists in at least two forms, MAO-A and MAO-B. These are differentiated by their substrate-specificities (Tipton et al 1983; Fowler et al 1981) and their inhibitor sensitivities (Johnston 1968; Knoll & Magyar 1972). Semicarbazide-sensitive amine oxidase (SSAO) is another enzyme with a widespread distribution in man and rat, particularly in aorta and lung (Lewinsohn et al 1978, 1980). This enzyme has also been called plasma or serum amine oxidase, benzylamine oxidase (BZAO) because it is able to catalyse the oxidation of benzylamine (Lewinsohn et al 1978, 1980), or clorgyline-resistant amine oxidase, as it is resistant to inhibition by clorgyline at in-vitro concentrations that are sufficient to inhibit MAO-A and MAO-B activities completely (Lyles & Callingham 1982).

The metabolism of catecholamines and 5-hydroxytryptamine (5-HT) in brain first involves their deamination to aldehydes, a reaction catalysed by MAO. These biogenic aldehydes are then either oxidized to acids by aldehyde dehydrogenase (ALDH, EC 1.2.1.3) or reduced to alcohols by NADPH-dependent aldehyde reductases (AR, EC 1.1.1.2) (Tipton et al 1977).

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There are two major forms of AR in mammalian brain (Turner & Tipton 1972; Ris et al 1975: O'Brien & Schofield 1980); that predominating has been called the high-K_m form (Turner & Tipton 1972). This enzyme is almost certainly identical with pig kidney (Flynn et al 1975), pig liver (Branlant & Biellman 1980) and human liver AR (Wermuth et al 1977). The other major AR in brain is the low-K_m form which is less sensitive to anticonvulsant drugs than the high-K_m form (Whittle & Turner 1978) and appears to be responsible for the reduction of aldehydes formed by deamination of monoamines (Turner et al 1974: Anderson et al 1976; Whittle & Turner 1981). This latter enzyme appears, on immunological and other criteria, to be identical with aldose reductase (EC 1.1.1.21) (Dons & Doughty 1976; Hoffmann et al 1980; Whittle & Turner 1981), the enzyme responsible for the reduction of glucose to sorbitol in several tissues (O'Brien & Schofield 1980).

Age-related changes in MAO-A, MAO-B, SSAO, ALDH and AR have been reported in different tissues of laboratory animals (Lowe et al 1975; Shih 1979; Della Corte & Callingham 1977; Strolin Benedetti & Keane 1980; Cao Danh et al 1983, 1984a, b) and in man (Gottfries et al 1975; Robinson et al 1972; Oreland & Fowler 1979). Surprisingly, age-related changes of these enzymes in the eye do not appear to have been studied, although catecholamines are involved in the regulation of intraocular pressure, thus suggesting a role for ocular tissue MAO, which might be modified by age. Moreover, glucose metabolism can be altered in ageing to produce sorbitol accumulation in the lens. Results from previous work (Aldinio et al 1979) were compatible with the fact that both cataract and glaucoma might involve changes, if any, in platelet MAO in the same direction and of similar magnitude. A published study (Gierkowa et al 1974) reports elevated serum amine oxidase activity in a group of postmenopausal women with glaucoma. The aim of the present work was to compare the MAO-A, MAO-B, SSAO and AR activities in the eye from young (3 months) and old (23–26 months) male Wistar rats.

Materials and methods

5-Hydroxytryptamine-[side chain-2-^{14}C] creatinine sulphate and [7-^{14}C]benzylamine hydrochloride were obtained from the Radiochemical Centre, Amersham, UK; β-phenylethylamine-[ethyl-1-^{14}C] hydrochloride (β-PEA) was obtained from New England Nuclear, Boston, Mass., USA; clorgyline hydrochloride was synthesized in the Department of Organic Chemistry, Centre de Recherche Delalande, France. The other reagents were standard laboratory reagents of analytical grade.

Male Wistar rats (Iffa Credo), aged 23–26 months (600–850 g) were compared with matched animals of 3 months (170–180 g). Animals were decapitated and eyes immediately removed, rinsed in saline (0·9% NaCl w/v), frozen in liquid nitrogen and stored at −20 °C.

Eye MAO and SSAO activities were measured by the micromethod of Clarke et al (1982) with some modifications, as described by Guffroy & Strolin Benedetti (1984). In all cases, the final substrate concentrations in the assay tubes were 400 μM for 5-HT, 50 μM for β-PEA and 1 μM for benzylamine (BZ). The initial velocities were measured. MAO and SSAO activity was expressed as nmol (of deaminated substrate) (mg protein)$^{-1}$ min^{-1}. Oxidative deamination of each substrate by MAO-A, -B and/or SSAO in eye was studied following the decrease of substrate oxidation as a function of increasing concentrations of a selective MAO-A or SSAO inhibitor, clorgyline and semicarbazide, as described by other authors.

For AR determination, eyes were removed, immediately weighed and homogenized (Potter-Elvehjem) in 9 volumes of 0·1 M sodium phosphate buffer (pH 7·0) containing 0·32 M sucrose and 1% Triton X-100 as previously described (Cao Danh et al 1984a). The homogenates were then centrifuged in a type R40 rotor at 105 000*g* for 60 min in a Spinco-Beckman model L5 ultracentrifuge. The supernatants were used to measure the activity of AR. This was assayed according to Reyes & Erwin (1977) with four substrates (D-glucose, D-glucuronate, D-xylose, DL-glyceraldehyde) in the eye of old rats compared with matched animals of 3 months. The substrate and protein concentrations used are in Results. AR activity was determined spectrophotometrically by following the rate of NADP formation at 340 nm. Protein concentration was determined by the method of Lowry et al (1951) with bovine serum albumin as standard.

Statistical analyses were made using Student's *t*-test when the hypothesis of equal variance was valid as evaluated by the Fisher test, and the Wilcoxon nonparametric test when this hypothesis was rejected.

Results

Protein content in the eye of young and old rats. A slight but significant ($P < 0·05$) decrease in protein concentration (mg (g fresh tissue)$^{-1}$ ± s.e.m) was found in the eye of old rats (81 ± 12) compared with young rats (131·9 ± 15·9) in the experiment where MAO-A and -B activities were determined (Table 2). But in the experiment where SSAO activity was measured (Table 1), no significant difference in the protein concentration was observed.

Inhibition of substrate deamination in eye of young and old rats by clorgyline. Oxidative deamination of 5-HT, β-PEA and BZ in the eye of young and old rats as a function of increasing concentrations of clorgyline is presented in Fig. 1. In the eye of both young and old rats, 5-HT is metabolized only by MAO-A and β-PEA by MAO-B, even though a small contribution by the A form is clearly visible, in so far as the latter is concerned (Fig. 1). Fig. 1 shows that the oxidative deamination of 1 μM BZ is hardly affected by MAO, although a small

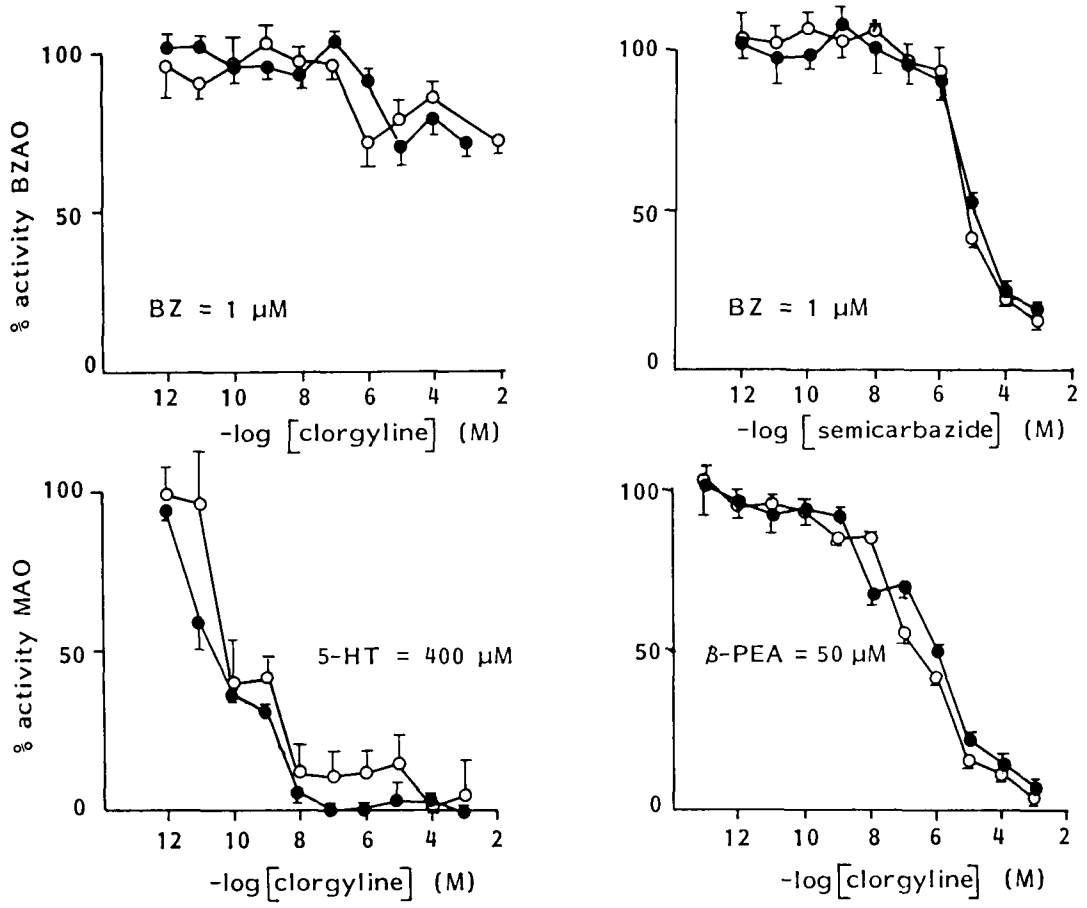

FIG. 1. Oxidative deamination of BZ, 5-HT and β-PEA in the eye of young (○) and old (●) rats as a function of increasing concentration of a selective MAO-A inhibitor (clorgyline) or SSAO inhibitor (semicarbazide). Each point represents the mean ± s.e.r. (determinations in triplicate).

contribution by the -B form in eye of both young and old rats can be observed.

Inhibition of BZ deamination in eye of young and old rats by semicarbazide. Fig. 1 also shows that, in the eye, 1 μM BZ is mainly a substrate of SSAO in young and old rats.

Changes in SSAO activity with age in rat eye. SSAO activity in the rat eye is low compared with tissues such as aorta (Cao Danh et al 1984b), duodenum and lung, but it is comparable to that in kidney (Cao Danh 1984c). SSAO activity was measured in the presence and absence of clorgyline. A significant decrease (18–23%) in enzyme activity was found in the eye of old rats (Table 1).

Changes in MAO-A and MAO-B activity with age in rat eye. MAO activity in the rat eye is low compared with the other tissues studied (Cao Danh et al 1985). A significant decrease in both MAO-A and -B activity was found in the eye of old rats when enzyme activity was expressed g^{-1} of tissue whereas no significant change was found when enzyme activity was expressed mg^{-1} of protein (Table 2).

Changes in AR activity with age in rat eye. AR activity in the eye is lower than that detected in brain, liver and heart (Cao Danh et al 1984a). AR activity in the eyes of young and old rats was assayed using various aldehydes as substrates. A significant increase of AR activity was found with D-glucose (21%), DL-glyceraldehyde (64%), D-xylose (67%) and D-glucuronate (43%) (Table 3). Moreover, an additional experiment (n = 6) was carried out using 100 mM D-xylose as substrate in the presence of sodium valproate (DPA) (1 mM), as described by Cao Danh et al (1984a). The increase of AR activity in the presence of DPA was 67 ± 7% (mean ± s.e.r.) whereas in the absence of DPA it was 57 ± 4% (mean ± s.e.r.).

Table 1. Oxidative deamination of BZ by eye homogenates of young and old rats with and without clorgyline (0·1 mM). Final concentration: BZ: 1 μM. SSAO activity is expressed as nmol (g of tissue)$^{-1}$ or (mg of protein)$^{-1}$ min^{-1}, n = 6. Student's *t*-test or Wilcoxon test, $^{*}P < 0.05$.

Young rats mean ± s.e.m.	Old rats mean ± s.e.m.	$\frac{\text{Old}}{\text{Young}} \times 100$ mean ± s.e.r.
without clorgyline		
0·51 ± 0·02	0·41 ± 0·04	81 ± 8*
(0·0030 ± 0·0001)	(0·0025 ± 0·0002)	(82 ± 8)*
with clorgyline (0·1 mM)		
0·49 ± 0·02	0·39 ± 0·05	78 ± 10
(0·0029 ± 0·0001)	(0·0023 ± 0·0002)	(77 ± 9)*

Table 2. Oxidative deamination of 5-HT and β-PEA by eye homogenates of young and old rats. Final concentrations: 5-HT: 400 μM, β-PEA: 50 μM. MAO activity is expressed as nmol (g of tissue)$^{-1}$ or (mg of protein)$^{-1}$ min^{-1}, n = 6. Student's *t*-test or Wilcoxon test, $^{**}P < 0.01$.

Substrate	Young rats mean ± s.e.m.	Old rats mean ± s.e.m.	$\frac{\text{Old}}{\text{Young}} \times 100$ mean ± s.e.r.
β-PEA	5·79 ± 0·29	4·09 ± 0·44	71 ± 8**
	(0·046 ± 0·005)	(0·055 ± 0·009)	(119 ± 23)
5-HT	21·30 ± 1·75	13·22 ± 0·388	62 ± 5**
	(0·169 ± 0·016)	(0·180 ± 0·023)	(107 ± 17)

Discussion

The present results show that the oxidative deamination of 1 μM BZ is mainly carried out by SSAO, although a small contribution of MAO-B is evident in the eye of both young and old rats. 400 μM 5-HT is practically metabolized only by MAO-A in rat eye, whereas 50 μM β-PEA is preferentially metabolized by MAO-B, but with a small contribution from MAO-A. In the present work, when enzyme activity is expressed as nmol min^{-1} (g of tissue)$^{-1}$, SSAO, MAO-A and MAO-B activities decreased in eye of old rats compared to young rats. SSAO activity in eye of old rats also decreased when enzyme activity is expressed as nmol min^{-1} (mg protein)$^{-1}$, which is not the case for MAO. In our previous studies (Cao Danh et al 1984c, 1985), age-related changes in MAO-A, MAO-B and SSAO activities have been observed in various tissues of rats. A significant increase of MAO-B was found in brain and liver, and a particularly important increase of MAO-A in the heart, with a significant increase in liver too. Both MAO-A and -B activities decreased significantly in the lung of old rats (Cao Danh et al 1985), as well as SSAO activity (Cao Danh et al 1984c). These results demonstrate that ageing exerts specific changes in MAO-A, -B, and SSAO activities of brain and peripheral organs in the rat. It seems likely that alterations in membranes contribute to changes of MAO and SSAO activities in old rat tissues (Huang & Faulkner 1980; Nohl & Krämer 1980). The present results show that AR activity increased in the eye of old rats with D-glucose, D-xylose, DL-glyceraldehyde and D-glucuronate as substrates. D-Glucuronate provides a convenient means for assaying the high-K_m valproate-sensitive reductase exclusively, at least in rat brain (Turner & Whittle 1981); D-xylose has been chosen as the model substrate for the low-K_m aldehyde reductase which, when from pig brain and kidney, is immunologically identical with pig lens aldose reductase (Turner et al 1982; Cromlish & Flynn 1983); D-glucose is also a preferential substrate for the low-K_m aldehyde reductase. Reduction of glucose to sorbitol has been attributed to the enzyme aldose reductase, and therefore to the low-K_m aldehyde reductase. Therefore, both high-K_m and low K_m aldehyde reductases seem to increase in rat eye with age, in contrast to brain, where only the high-K_m form seems to increase with age (Cao Danh et al 1984a). Preliminary data on sorbitol dehydrogenase (EC 1.1.1.14) show no significant changes of this enzyme in rat eye with age (Cao Danh et al, unpublished results). If the same is true in man, under conditions of severe diabetic hyperglycaemia, age can aggravate the sorbitol accumulation in the lens responsible for diabetic cataractogenesis, whereas age should have virtually no effect on the accumulation of sorbitol in the brain, which is considered to be the causative agent in the development of fatal cerebral oedema (O'Brien & Schofield 1980).

The results of the present work on changes in SSAO, MAO-A, MAO-B and AR activity with age in rat eye favour a decrease of ocular levels of aldehydes in old rats. Preliminary results on AR activity (mean ± s.e.m., n = 6) in rat lens using 100 mM D-xylose as substrate have shown no statistically significant difference between old rats (0·99 ± 0·05 nmol NADPH oxidized min^{-1} (mg of protein)$^{-1}$) and young rats (0·93 ± 0·04 nmol NADPH oxidized min^{-1} (mg of

Table 3. AR activity in eye of young and old rats. AR activity is expressed as nmol NADPH oxidized min^{-1} mg^{-1} of protein ± s.e.m., n = 6. $^{*}P < 0.05$, $^{**}P < 0.001$.

Substrate (μmol/assay)	Protein (mg/assay)	Young rats mean ± s.e.m.	Old rats mean ± s.e.m.	$\frac{\text{Old}}{\text{Young}} \times 100$ mean ± s.e.r.
D-Glucose (400)	2·0–6·0	0·26 ± 0·01	0·32 ± 0·02	121 ± 10*
DL-Glyceraldehyde (5)	3·0–4·5	0·52 ± 0·01	0·85 ± 0·02	164 ± 6**
D-Xylose (100)	2·0–5·0	0·31 ± 0·01	0·52 ± 0·02	167 ± 9**
D-Glucuronate (10)	3·2–5·5	0·52 ± 0·02	0·75 ± 0·03	143 ± 8**

protein)$^{-1}$) (Cao Danh et al, unpublished results). Therefore, our results do not explain how β-carboline condensation products seem to occur in ageing human lens tissue (Collins 1980; Dillon et al 1976) and have been implicated as part of the cellular ageing phenomenon. But whether these condensation products are the result of the condensation of α-ketoacids or aldehydes with tryptophan has yet to be resolved.

REFERENCES

Aldinio, C., Cerletti, C., Manara, L., Recchia, M., Carlevaro, G., de Molfeta, V. (1979) Invest. Ophthalmol. Visual Sci. 18: 320–324

Anderson, R. A., Meyerson, L. R., Tabakoff, B. (1976) Neurochem. Res. 1: 525–540

Branlant, G., Biellman, J. F. (1980) Eur. J. Biochem. 105: 611–621

Cao Danh, H., Strolin Benedetti, M., Dostert, P. (1983) J. Neurochem. 41: 618–622

Cao Danh, H., Strolin Benedetti, M., Dostert, P. (1984a) Gerontology 30: 159–166

Cao Danh, H., Strolin Benedetti, M., Dostert, P., Mousset, A. (1984b) J. Pharm. Pharmacol. 36: Suppl. Amine Oxidases, A Cambridge Workshop, 4–6 August 1984, 27W

Cao Danh, H., Strolin Benedetti, M., Dostert, P., Mousset, A. (1984c) J. Pharm. Pharmacol. 36: 592–596

Cao Danh, H., Strolin Benedetti, M., Dostert, P. (1985) in: Tipton, K. F., Dostert, P., Strolin Benedetti, M. (eds) Monoamine oxidase and disease. Prospects for therapy with reversible inhibitors. Academic Press, London, pp 301–317

Clarke, D. E., Lyles, G. A., Callingham, B. A. (1982) Biochem. Pharmacol. 31: 27–35

Collins, M. A. (1980) Adv. Exp. Med. Biol. 126: 87–102

Cromlish, J. A., Flynn, T. G. (1983) J. Biol. Chem. 258: 3583–3586

Della Corte, L., Callingham, B. A. (1977) Biochem. Pharmacol. 26: 407–415

Dillon, J., Spector, A., Nakanishi, K. (1976) Nature, 259: 422–423

Dons, R. F., Doughty, C. C. (1976) Biochim. Biophys. Acta 452: 1–12

Flynn, T. G., Shires, J., Walton, D. J. (1975) J. Biol. Chem. 250: 2933–2940

Fowler, C. J., Oreland, L., Callingham, B. A. (1981) J. Pharm. Pharmacol. 33: 341–347

Gierkowa, A., Koraszewska-Matuszewska, B., Matsuzewski, W. (1974) Klin. Oczna 44: 3

Gottfries, C. G., Oreland, L., Wiberg, A., Winblad, B. (1975) J. Neurochem. 25: 667–673

Guffroy, C., Strolin Benedetti, M. (1984) Life Sci. 34: 535–545

Hoffman, P. L., Wermuth, B., von Wartburg, J. P. (1980) J. Neurochem., 35: 354–366

Huang, R. H., Faulkner, R. (1980) Mol. Pharmacol. 18: 267–273

Johnston, J. P. (1968) Biochem. Pharmacol. 17: 1285–1297

Knoll, J., Magyar, K. (1972) Adv. Biochem. Psychopharmacol. 5: 393–408

Lewinsohn, R., Böhm, K. H., Glover, V., Sandler, M. (1978) Biochem. Pharmacol. 27: 1857–1863

Lewinsohn, R., Glover, V., Sandler, M. (1980) Ibid. 29: 1221–1230

Lowe, M. C., Reichenbach, D. D., Horita, A. (1975) J. Pharmacol. Exp. Ther. 194: 522–536

Lowry, O. H., Rosebrough, N. J., Farr, A. L., Randall, R. J. (1951) J. Biol. Chem. 193: 265–275

Lyles, G. A., Callingham, B. A. (1982) Biochem. Pharmacol. 31: 1417–1424

Nohl, H., Krämer, R. (1980) Mech. Ageing Dev. 14: 137–144

O'Brien, M. M., Schofield, P. J. (1980) Biochem. J., 187: 21–30

Oreland, L., Fowler, C. J. (1979) in: Singer, T. P., Von Korff, R. W., Murphy, D. L. (eds) Monoamine Oxidase: Structure, function and altered functions. Academic Press, New York, 389–396

Reyes, E., Erwin, V. G. (1977) Neurochem. Res. 2: 87–97

Ris, M. M., Deitrich, R. A., von Wartburg, J. P. (1975) Biochem. Pharmacol. 24: 1865–1869

Robinson, D. S., Davis, J. M., Nies, A., Colburn, R. W., Davis, J. N., Bourne, H. R., Bunney, W. E., Shaw, D. M., Coppen, A. J. (1972) Lancet, 1: 290–291

Shih, J. C. (1979) in: Singer, T. P., Von Korff, R. W., Murphy, D. L. (eds) Monamine Oxidase: structure, function and altered functions. Academic Press, New York, 413–422

Strolin Benedetti, M., Keane, P. E. (1980) J. Neurochem. 35: 1026–1032

Tipton, K. F., Fowler, C. J., McCrodden, J. M., Strolin Benedetti, M. (1983) Biochem. J. 209: 235–242

Tipton, K. F., Houslay, M. D., Garrett, N. J. (1973) Nature New Biol. 246: 213–214

Tipton, K. F., Houslay, M. D., Turner, A. J. (1977) in: Youdim, M. B. H., Lovenberg, G. W., Sharman, D. F., Lagnado, J. R. (eds) Essay in neurochemistry and neuropharmacology, vol. 1. John Wiley & Son, London, pp. 103–138

Turner, A. J., Illingworth, J. A., Tipton, K. F. (1974) Biochem. J. 144: 353–360

Turner, A. J., Tipton, K. F. (1972) Ibid. 130: 765–772

Turner, A. J., Whittle, S. R. (1981) Biochem. Soc. Transac. 9: 279–281

Turner, A. J., Whittle, S. R., Hryszko, J., Guha, S. R. (1982) J. Neurochem. 39: 306–309

Wermuth, B., Munch, J. D. B., von Wartburg, J. P. (1977) J. Biol. Chem. 252: 3821–3828

Whittle, S. R., Turner, A. J. (1978) J. Neurochem. 31: 1453–1459

Whittle, S. R., Turner, A. J. (1981) Biochem. Biophys. Acta 657: 94–105