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Effects of Aluminium Chloride Exposure on the Histology of the Cerebral Cortex of Adult Wistar Rats

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Abstracts

Aluminium (Al) is presents in many manufactured foods, medicines and is also added to drinking water for purification purposes. Human exposure to Al has been increasing over the last decades. Al exposure and neurological impairments demonstrate mixed findings. The cerebral cortex is a sheet of neural tissue that is outer-most to the cerebrum of the mammalian brain and it plays a key role in memory, attention, perceptual awareness, thought, language, and consciousness.The objectives of this study was to investigate the possible effects that aluminium Chloride could have on the histology of cerebral cortex. Total of twenty adult wistar rats were used for this experiment. The wistar rats were divided into five groups; group I was the control, group II received 475mg/Kg, group III received 950mg/kg, group IV received 1,425mg/kg and group V received 1,900mg/kg via oral intubation for a duration of Eight weeks. The wistar rats were humanly sacrificed and the brain was removed and immediately fixed in bouin fluid. The histological observations of the aluminium treated groups revealed extensive neuronal vacuolation and necrosis (neuro-degeneration) of the cerebral cortex of wistar rats.Based on our observations, we therefore conclude that Aluminium chloride exposure has neurodegenerative effects on the histology of cerebral cortex of adult wistar rats especially at higher dose. Therefore, caution should be taken in its usage.

Keywords: Effects, Aluminium chloride, Exposure, Histology, Cerebral cortex, Wistar rats

1. Introduction:

Nervous system is a vulnerable target for toxicants due to critical voltages which must be maintained in the cells and the all responses when voltages reach threshold levels. Aluminium (Al) has the potential to be neurotoxic in human and animals. It presents in many manufactured foods and medicines and is also added to drinking water for purification purposes (Newairy et *al*., 2009). Al is widely used in antacid drugs, as well as, in food additives and tooth paste (Abbasali *et al*., 2005). Environmental pollution with different aluminium containing compounds, especially those in industrial waste expose people to higher than normal levels of Al (Kloppel *et al.*, 1997). Particulate matters distributed by cement – producing factories contain, high amount of Al, and animals and populations residing in the vicinity are exposed to the pollution (Shehla *et al*., 2001). Although, aluminum has been implicated in Alzheimer's disease, Parkinsonism, Dementia complex and causes extensive damage to the nervous system, to date the mechanism of Al neurotoxicity has not been fully elucidated (Niu *et al*., 2007). Patients on dialysis or on long-term treatment with total parenteral nutrition have been shown to accumulate this metal in different organs. (Alfrey et al., 1976; Yokel and McNamara, 2001; Klein, 1993). Al is a possible contributing factor in Alzheimer's disease (Campbell, 2002). Evidence for the contribution of Al to Alzheimer's disease (AD) remains contradictory (Flaten, 2001; Gupta et al., 2005). However, epidemiological studies have indicated a link between Al in drinking water and AD and a variety of human and animal studies have implicated learning and memory deficits after Al exposure. (Buraimoh et al., 2011a; Exley, 2005; Yokel, 2000).It was also postulated by Buraimoh et al., 2011b: that Aluminium chloride exposure has negative effects on behaviour of adult wistar rats (i.e. alter behaviour). It has been shown clearly that aluminium

accumulates in various mammalian tissues such as brain, bone, liver and kidney (Wills *et al*., 1993; Sahin *et al.*, 1994) and is accompanied by renal failure (Alfrey, 1980) or associated with age (Gómez *et al*., 1997).

The cerebral cortex is a sheet of neural tissue that is outer-most to the cerebral of the mammalian brain. It plays a key role in memory, attention, perceptual awareness, thought, language, and consciousness. It also integrates higher mental functions, general movement, visceral functions, and behavioral reactions. (Brodal, 1977;Cauller, 1995). It is constituted of up to six horizontal layers, each of which has a different composition in terms of neurons and connectivity. Neurons of the cerebral cortex are grouped into six main layers which include the following:

1. The molecular layer I
2. The external granular layer II
3. The external pyramidal layer III
4. The internal granular layer IV:
5. The internal pyramidal layer V
6. The multiform layer VI, (Jones,1998; Gilbert and Sigman, 2007; Shipp and Stewart., 2007)

1.1 Aims and Objectives

This study was designed in order to describe any possible effects (histological changes) that Aluminium Chloride exposure could have on the cerebral cortex of adult wistar rats.

2. Materials and Methods

This experiment was conducted in the Department of Human Anatomy, Faculty of Medicine, Ahmadu Bello University, Zaria, Kaduna State, Nigeria.

2.1 Experimental Animals

Twenty (20) Adult wistar rats were used for this experiment. The wistar rats were housed in a stainless steel cages maintained at standard environmental conditions (12h-12h light-dark cycle with light on at AM) with sufficient food, water and under good ventilation. The wistar rats were kept for two weeks (14days) before commencement of administration. This was to enable the wistar rats to acclimatise.

2.2 Experimental Design

The wistar rats were divided into five groups: control group I was given distil water while the four Aluminium exposed groups were given various concentrations of aluminium chloride as follows:

Group II received 475mg/Kg

Group III received 950mg/kg

Group IV received 1,425mg/kg

Group V received 1,900mg/kg (LD25)

The LD50 was 3,800mg/kg. The duration of administration was Eight weeks.

2.3 Experimental Procedure

After oral administration of various concentrations of Aluminium chloride to each group of the Wistar rats except group I (the control) for a duration of eight weeks, the wistar rats were humanly sacrificed and brain tissues were immediately removed and fixed in Bouin's fluid. Tissue preparation method for histological analysis was differentiated into the following stages; fixation, tissue processing, sectioning, staining and photomicrography. The tissue preparation was carried out using standard techniques in accordance with Gurr, (1962); Culling (1963); and Bradbury (1992). Haematoxylin and Eosin (H&E) staining was used to demonstrate general cell structure while Hirano-Zimman method was used for nerve cells and fibres (Hirano and Zimmerman, 1962; Luna, 1968).

3. Results

3a. Microscopic Examination of Tissues (H&E stain)

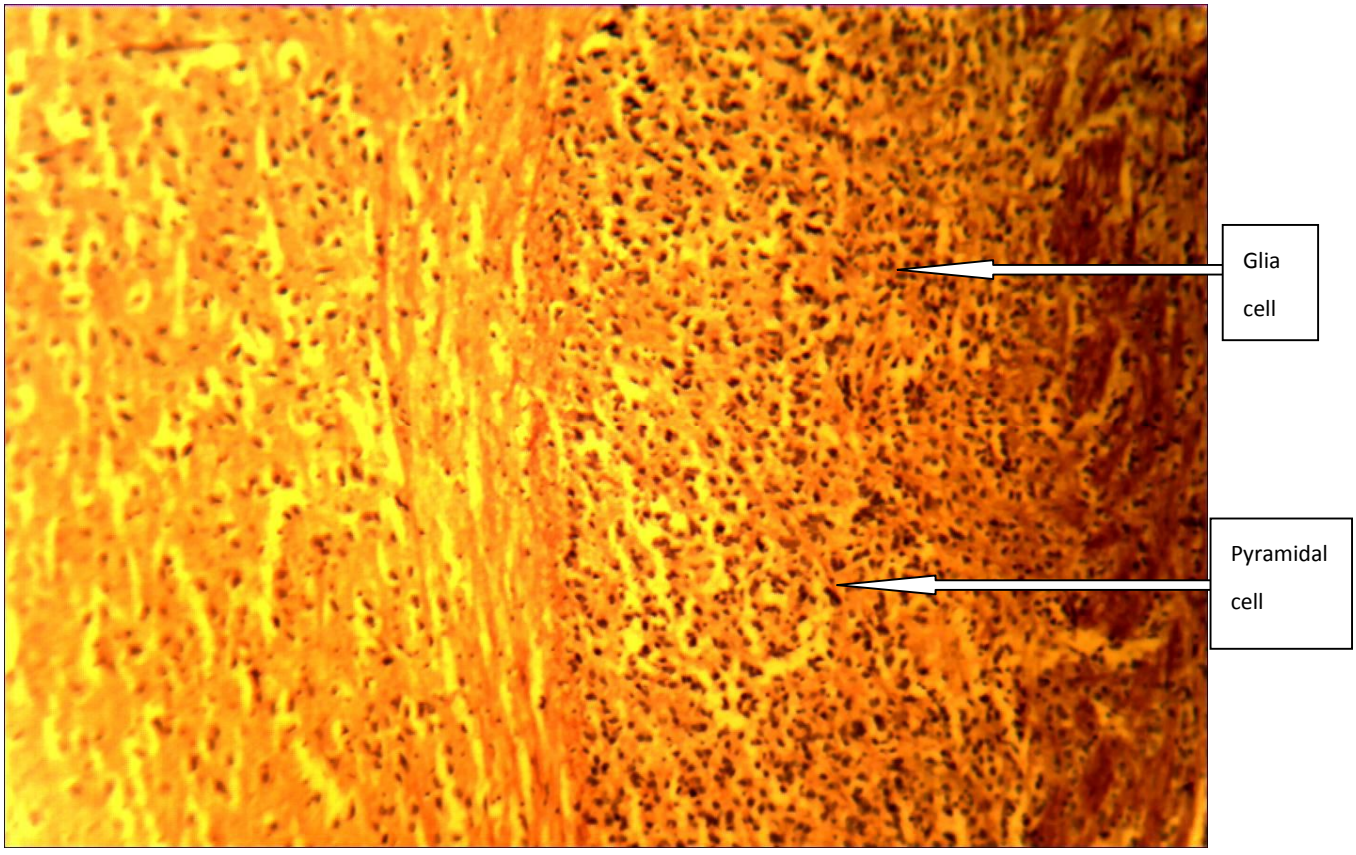

Plate 1: L.S. of Normal Cerebral Cortex of wistar rats of control group stained with H&E. X100

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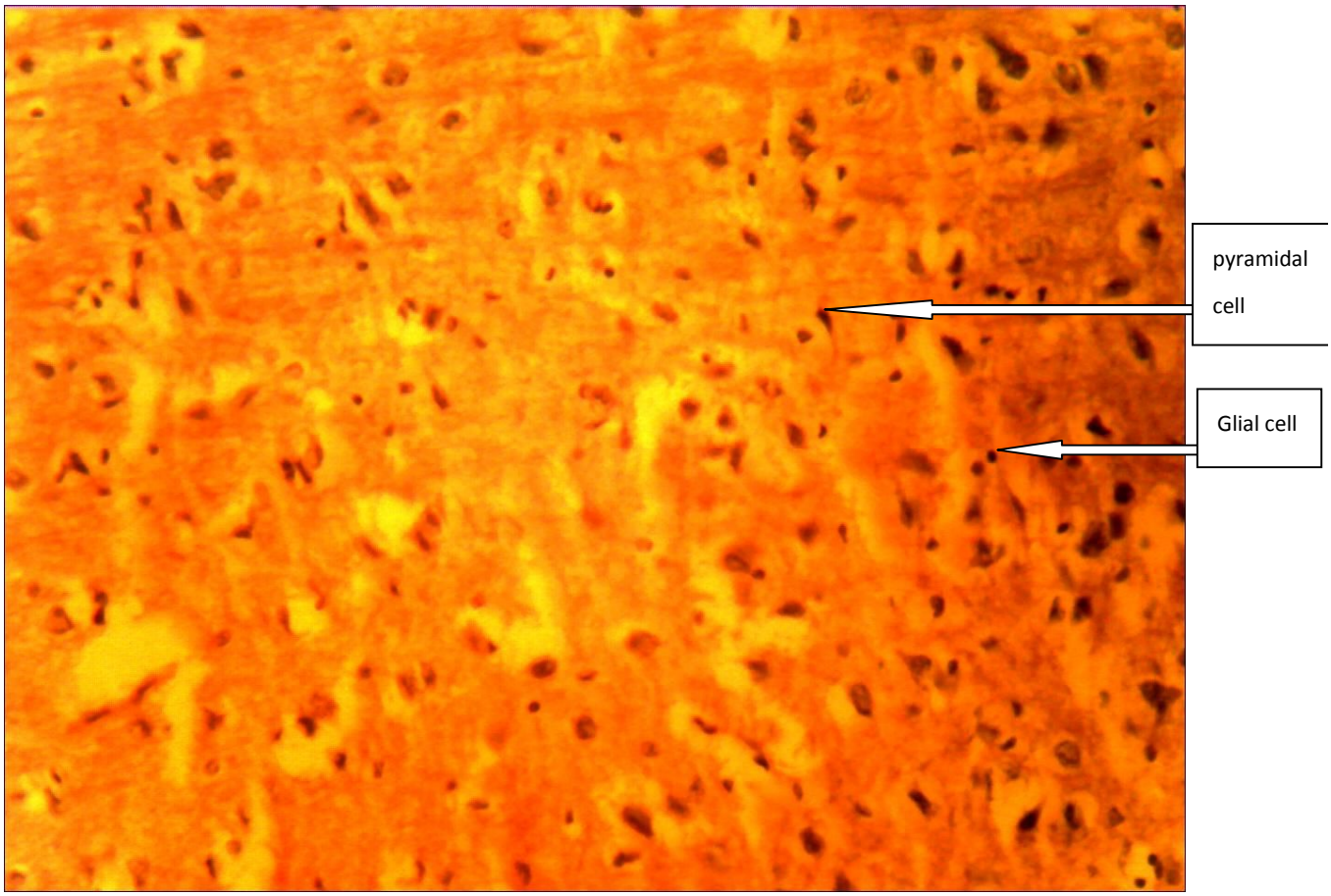

Plate 2: L.S. of Normal Cerebral Cortex of wistar rats of control group stained with H&E. Mag.X250

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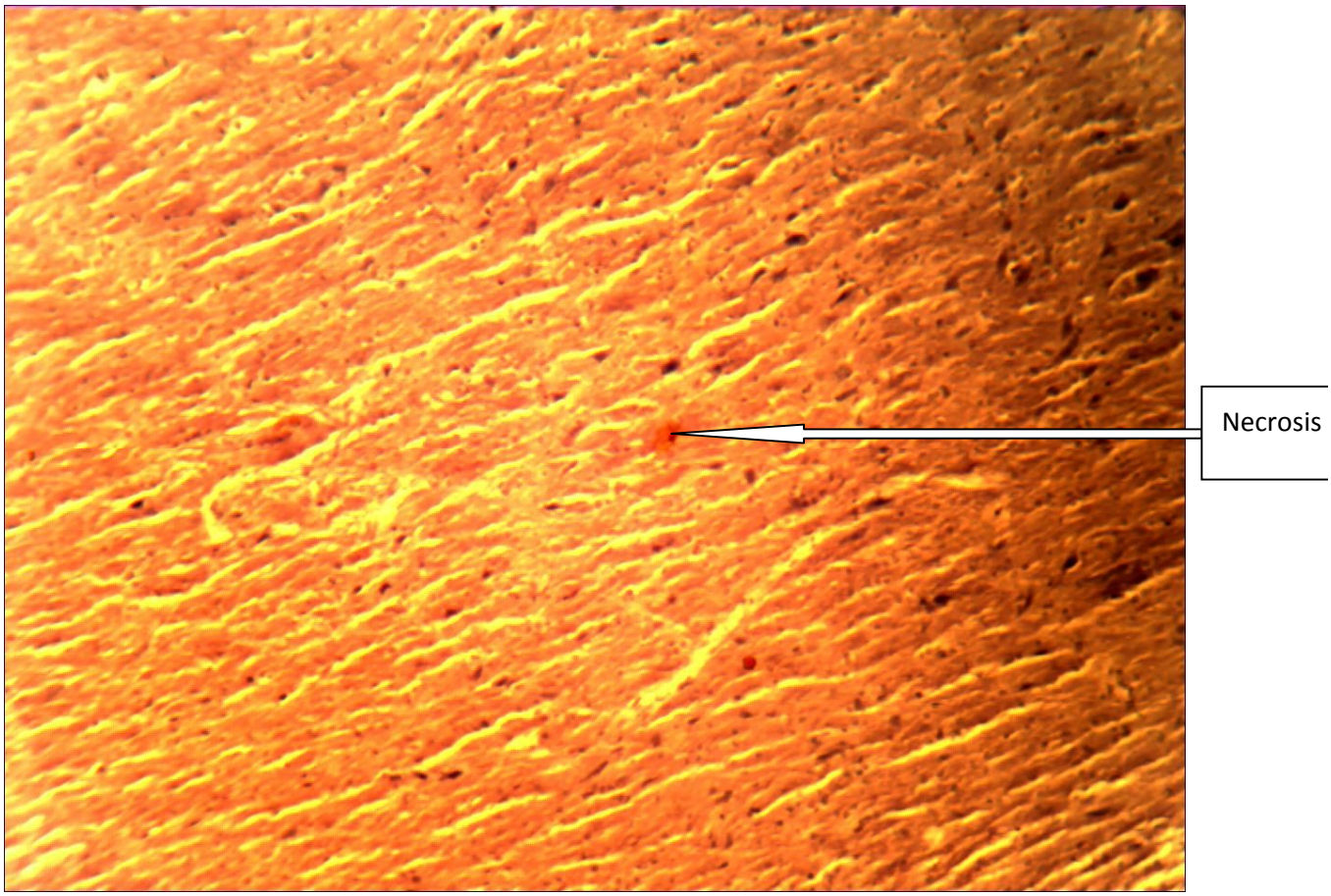

Plate 3. L.S. showing necrosis of the Cerebral Cortex of wistar rats of group II stained with H&E. X100

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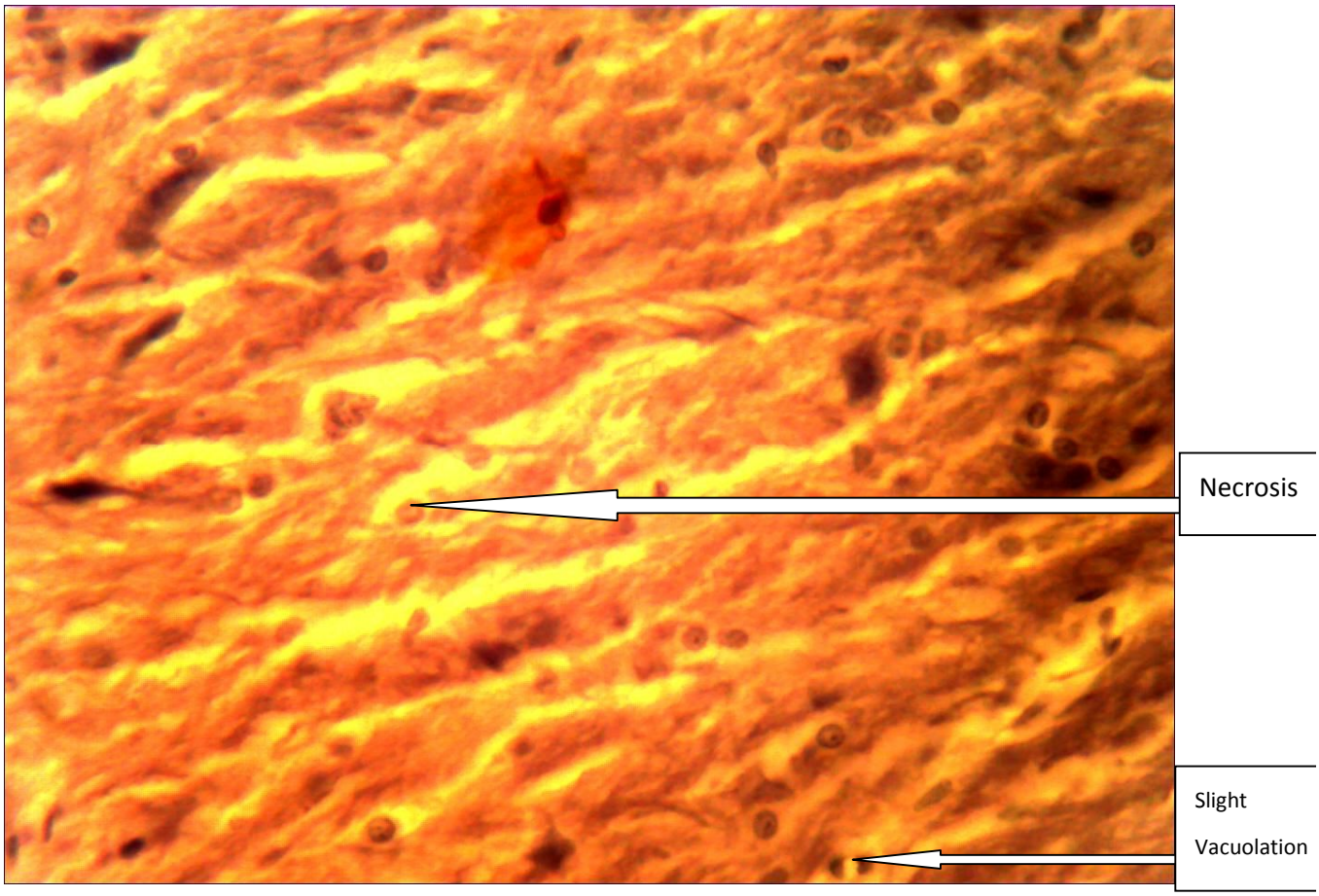

Plate 4. L.S. showing slight neuronal vacuolation and necrosis of the Cerebral Cortex of wistar rats of group II stained with H&E.X250

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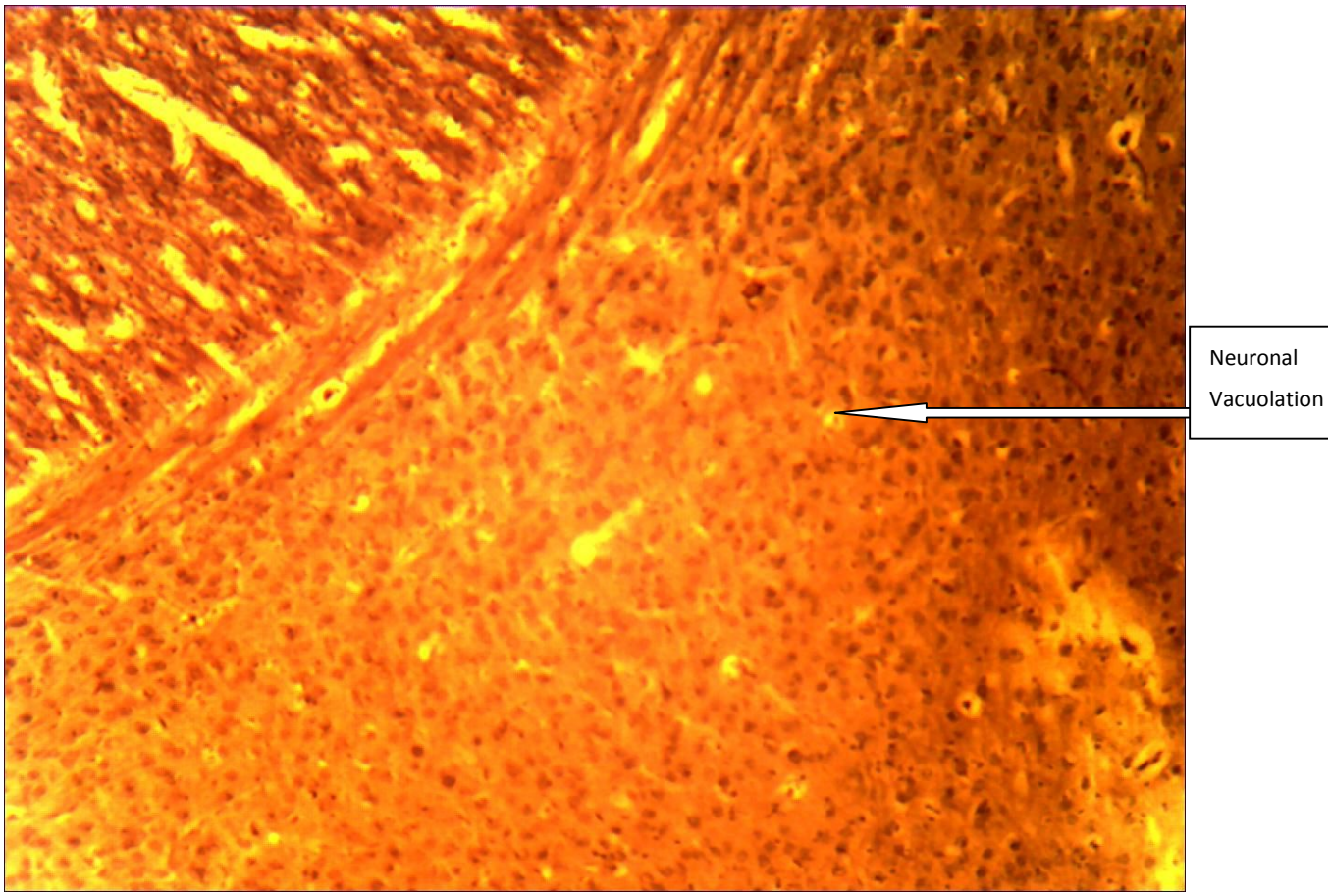

Plate 5. L.S. Showing slight neuronal vacuolation and Necrosis of the Cerebral Cortex of wistar rats of group III, stained with H&E. X100

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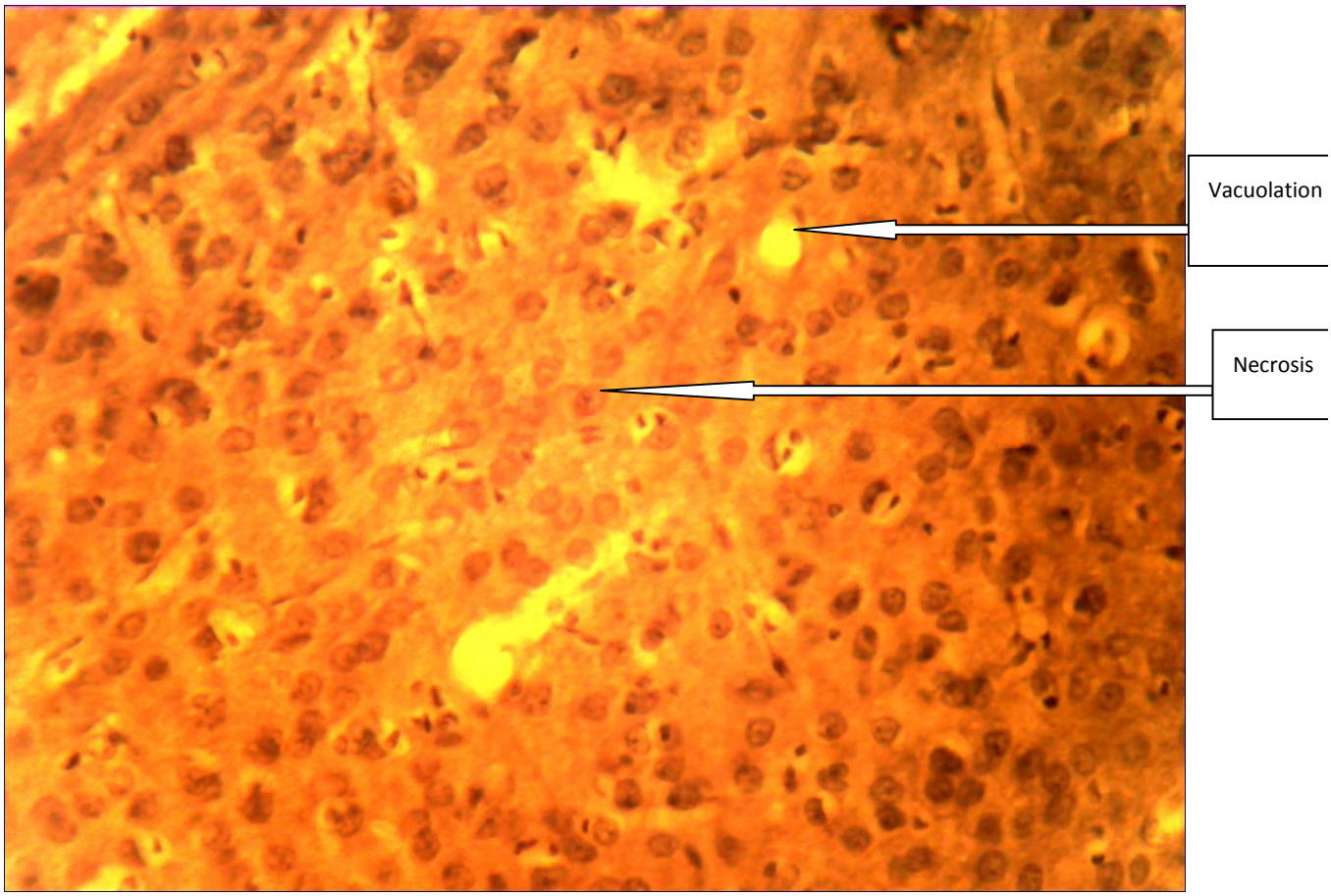

Plate 6. L.S. Showing slight neuronal vacuolation and Necrosis of the Cerebral Cortex of wistar rats of group III, stained with H&E.X250

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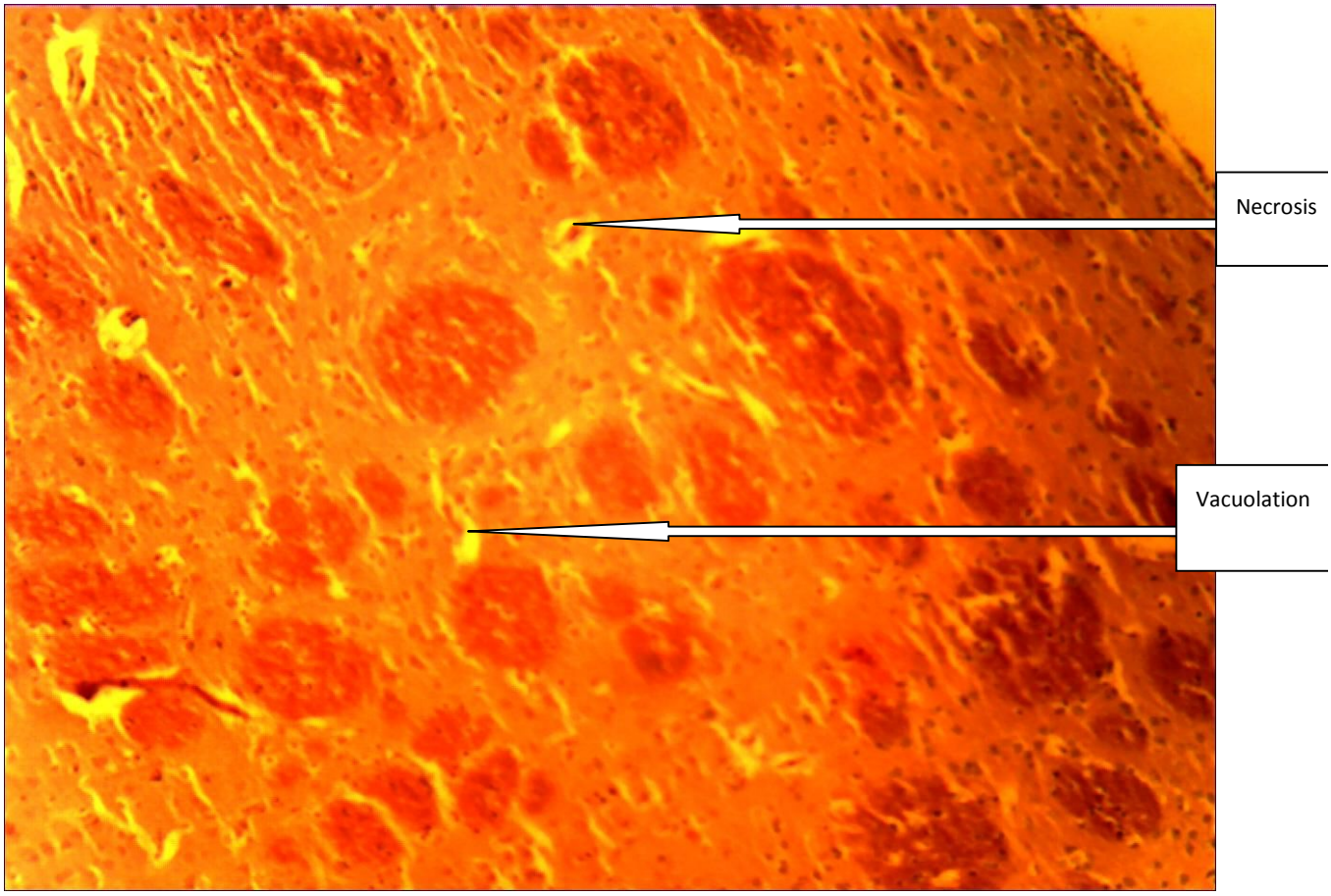

Plate 7. L.S. Showing neuronal vacuolation and Necrosis of the Cerebral Cortex of wistar rats of group IV, stained with H&E X100

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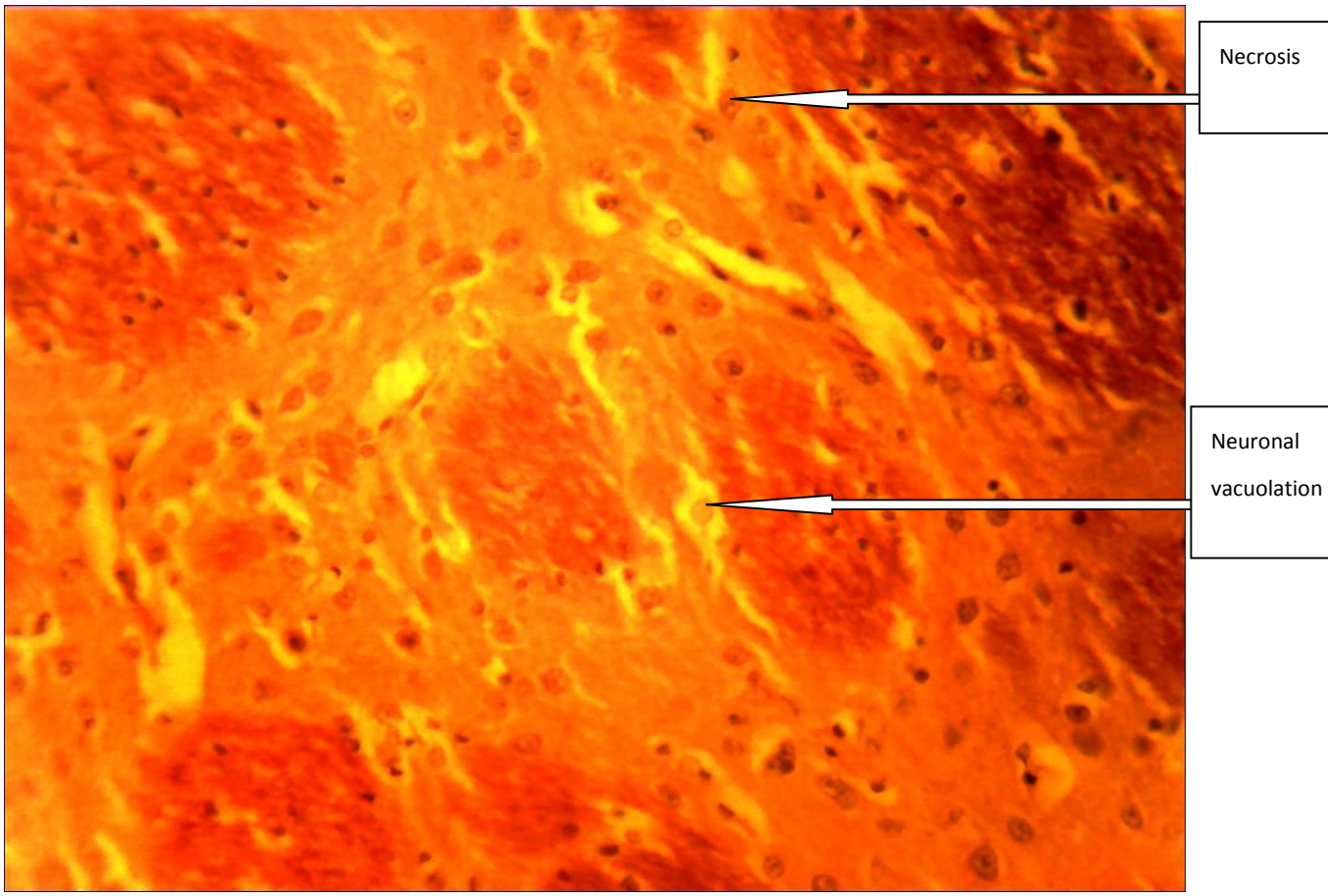

Plate 8. L.S. Showing slight neuronal vacuolation and Necrosis of the Cerebral Cortex of wistar rats of group IV, stained with H&E.X250

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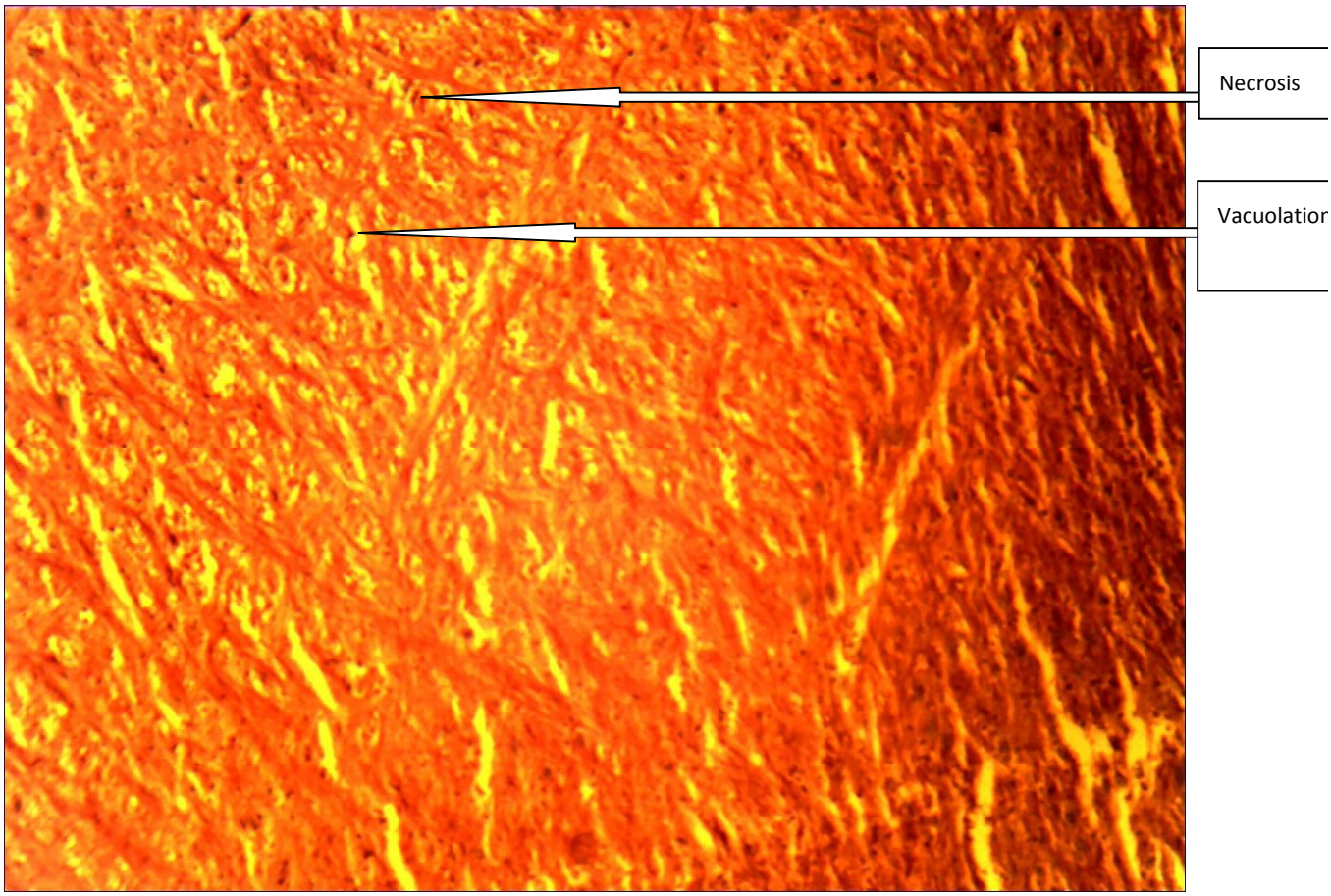

Plate 9. L.S Showing extensive neuronal Vacuolation and necrosis of the Cerebral Cortex of wistar rats of group V, stained with H&E. X100

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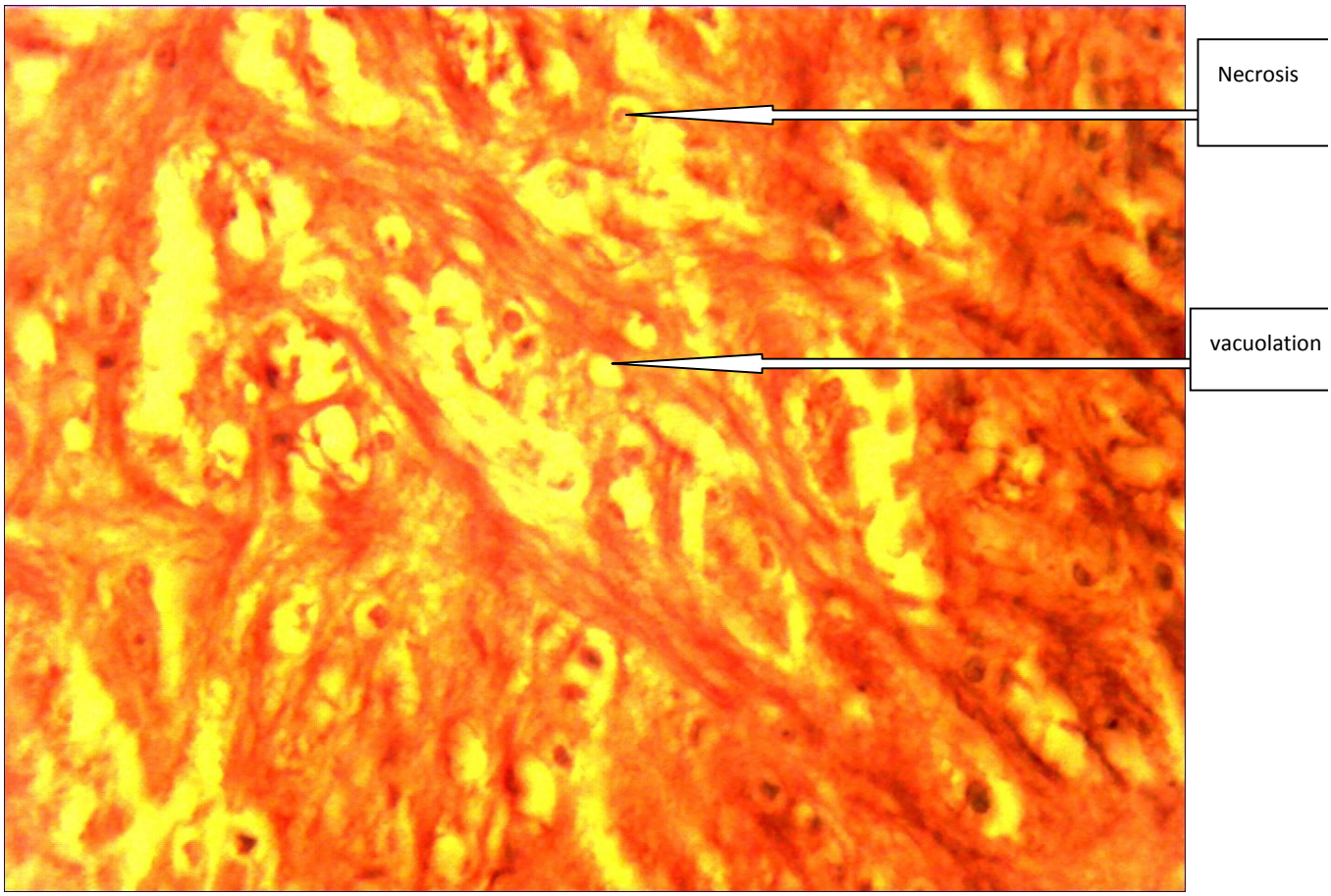

Plate 10.Showing extensive neuronal vaculation and necrosis of the Cerebral Cortex of wistar rats of group V, stained with H&E .X250

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3b. Microscopic Examination of Tissues (Hirano-Zimmerman method)

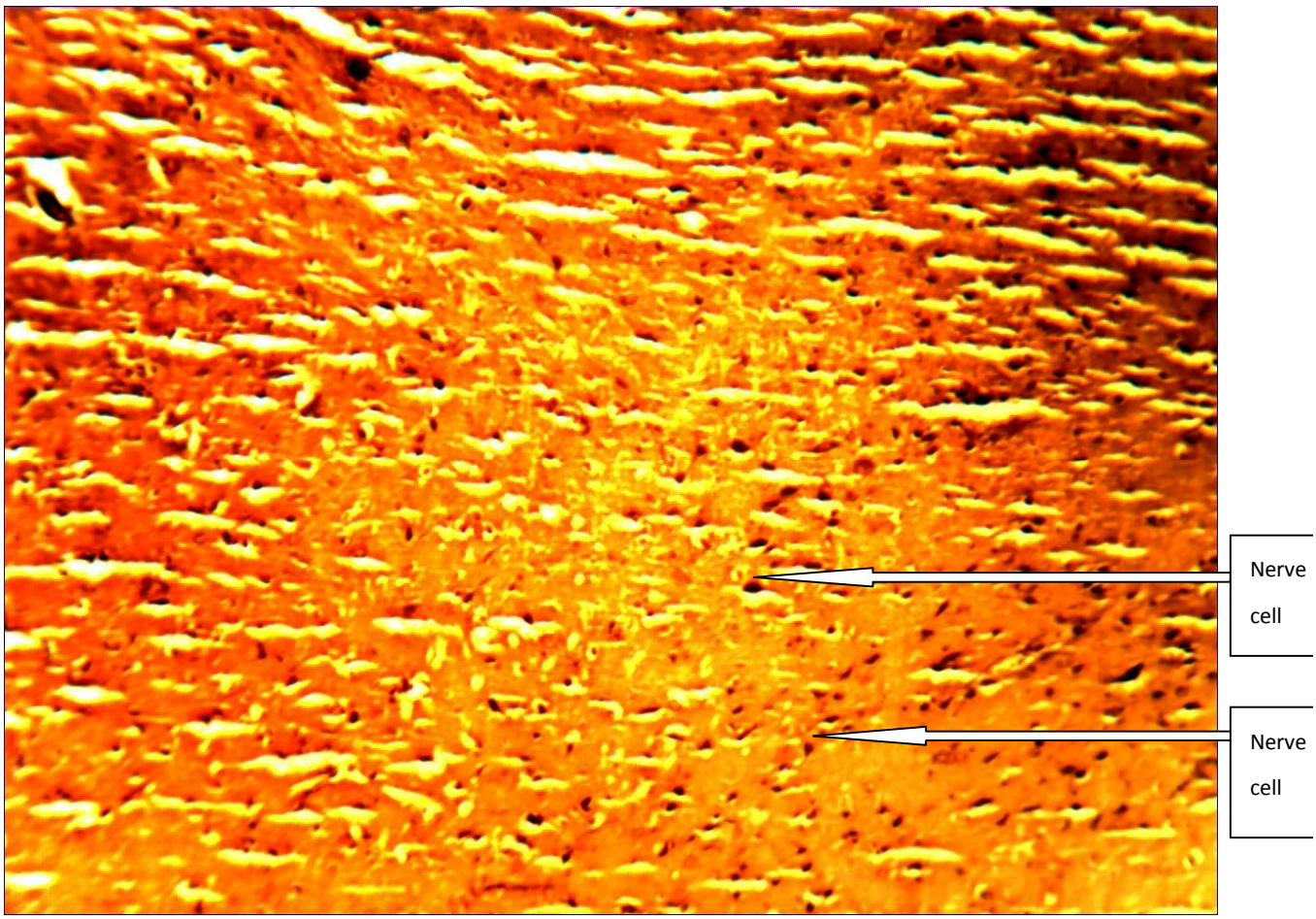

Plate 11. L.S. of normal Cerebral cortex of wistar rats of group I .X100

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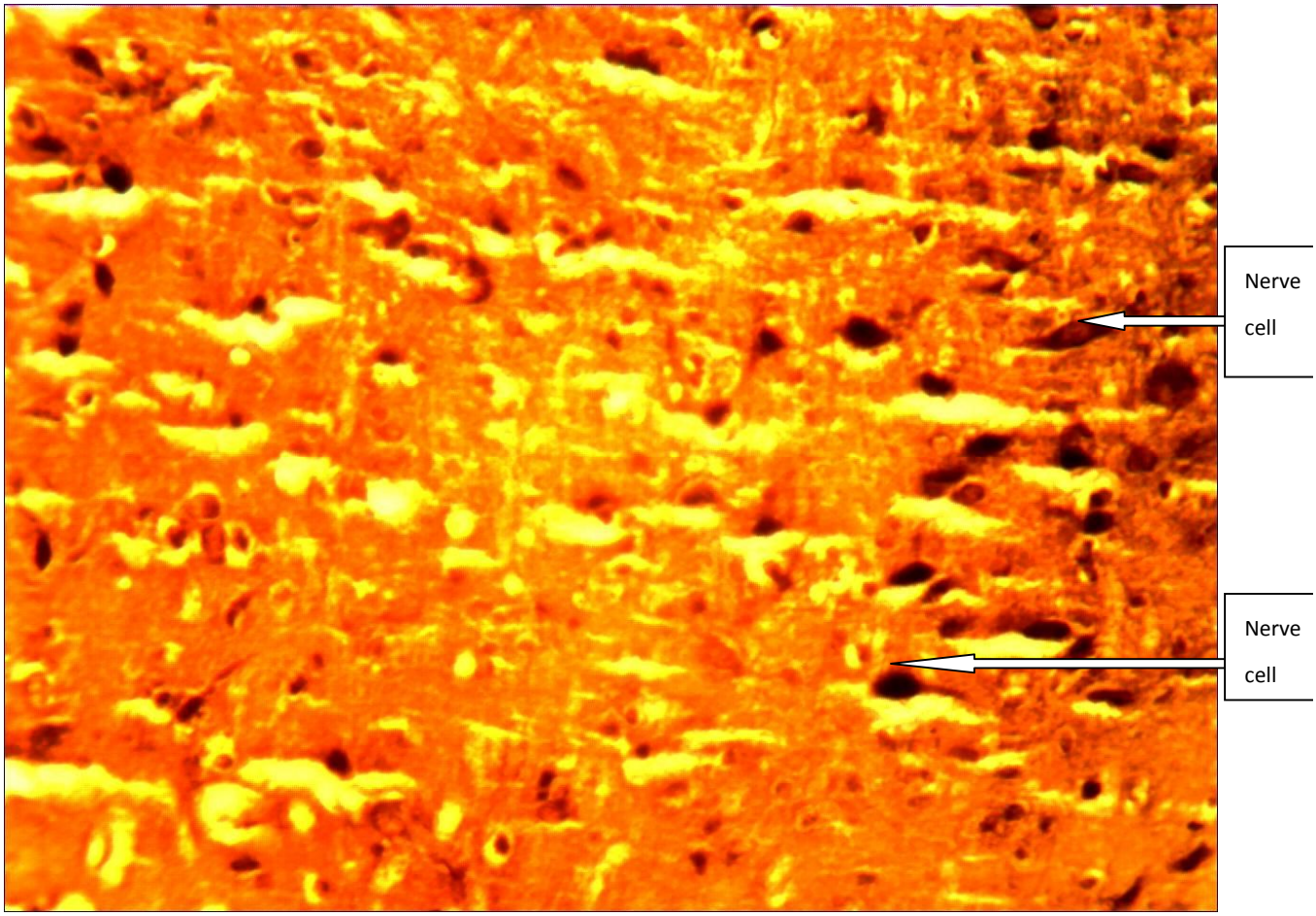

Plate 12. L.S. of normal Histology of the Cerebral Cortex of wistar rats of group I .X250

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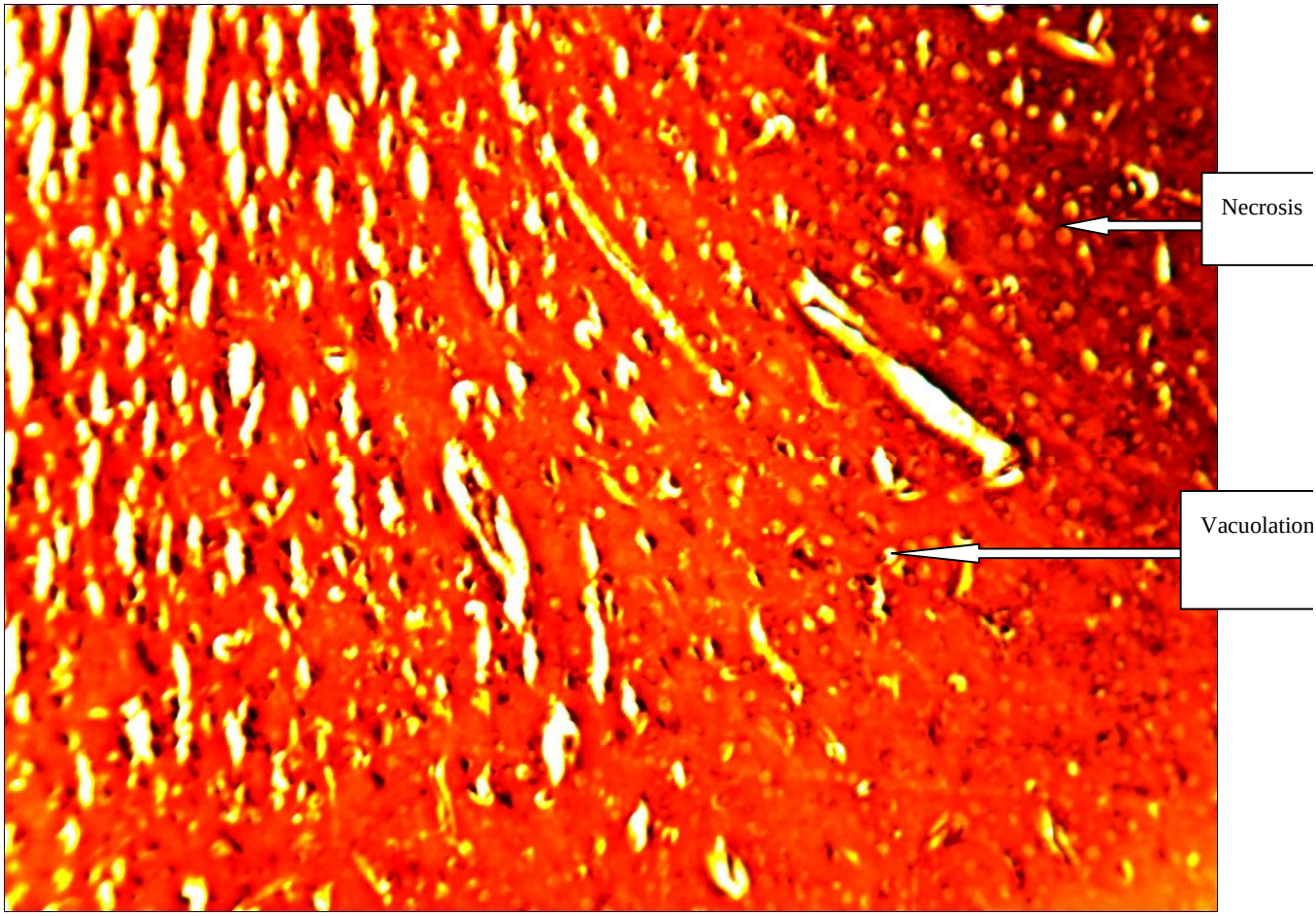

Plate 13. L.S. of neuronal vacuolation and necrosis of the Cerebral cortex of wistar rats of group II. X100

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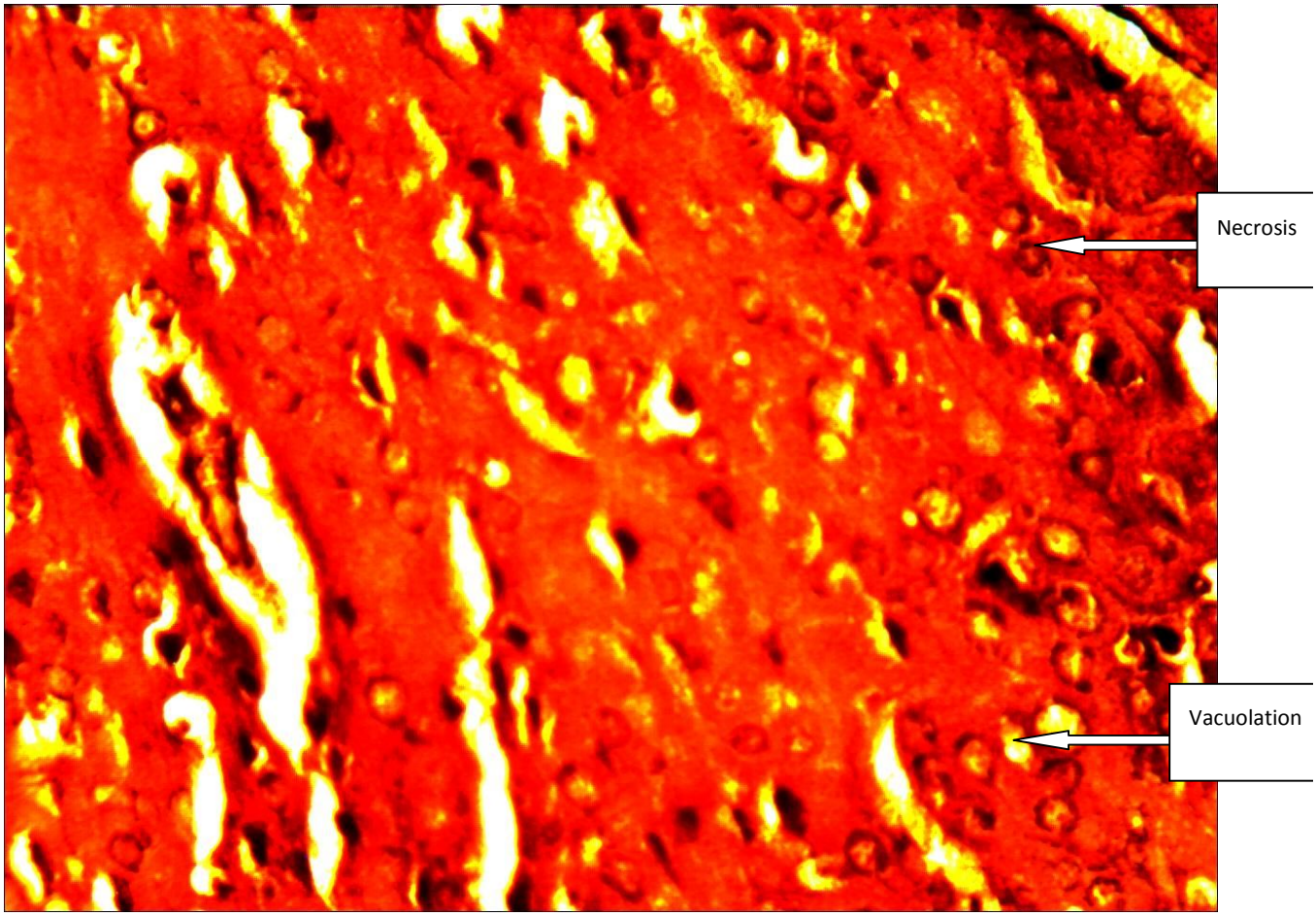

Plate 14. L.S. of neuronal vacuolation and necrosis of the cerbral Cortex of wistar rats of group II .X250

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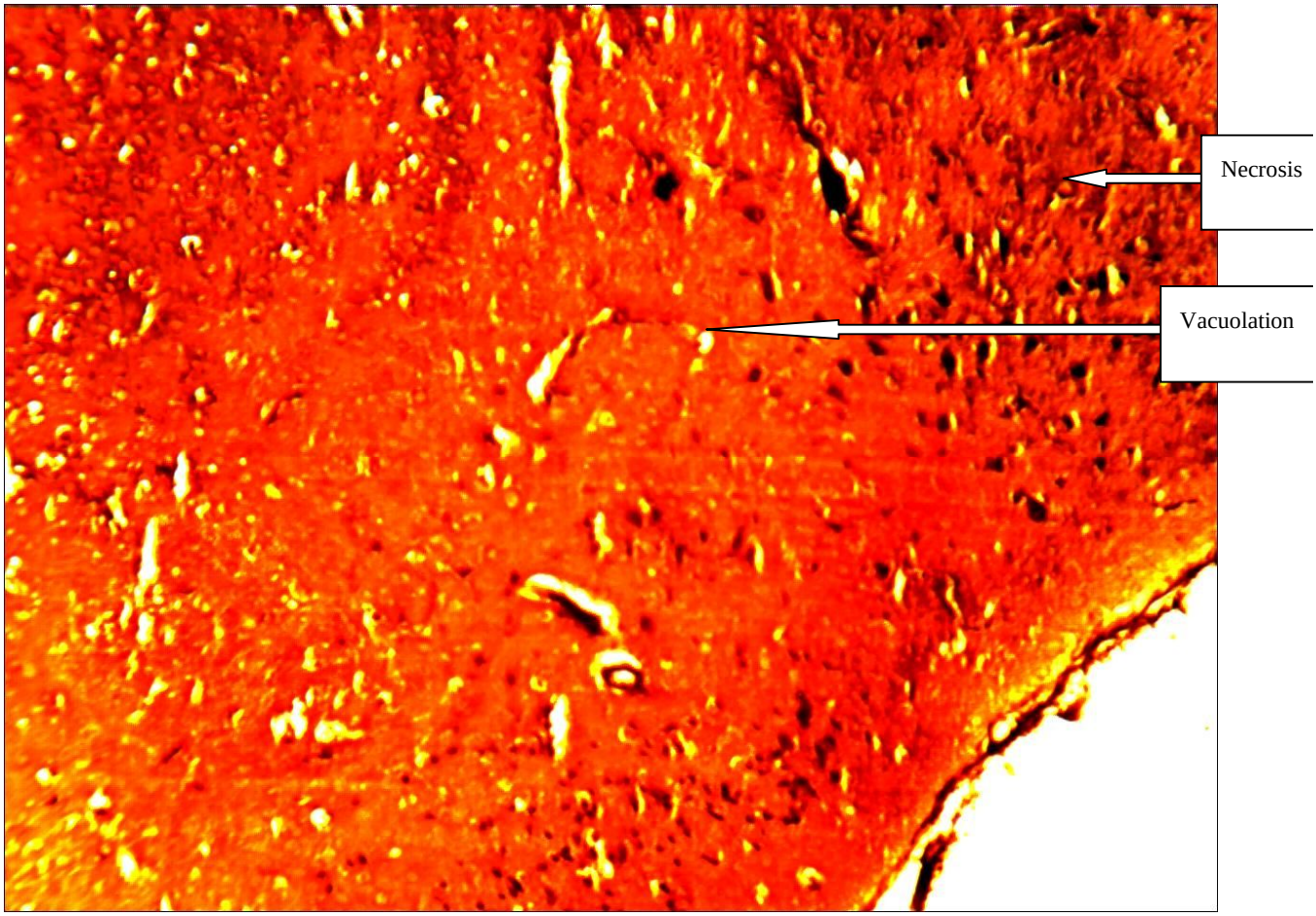

Plate 15.L.S.of neuronal vacuolation and necrosis of the cerbral Cortex of wistar rats of group III .X100

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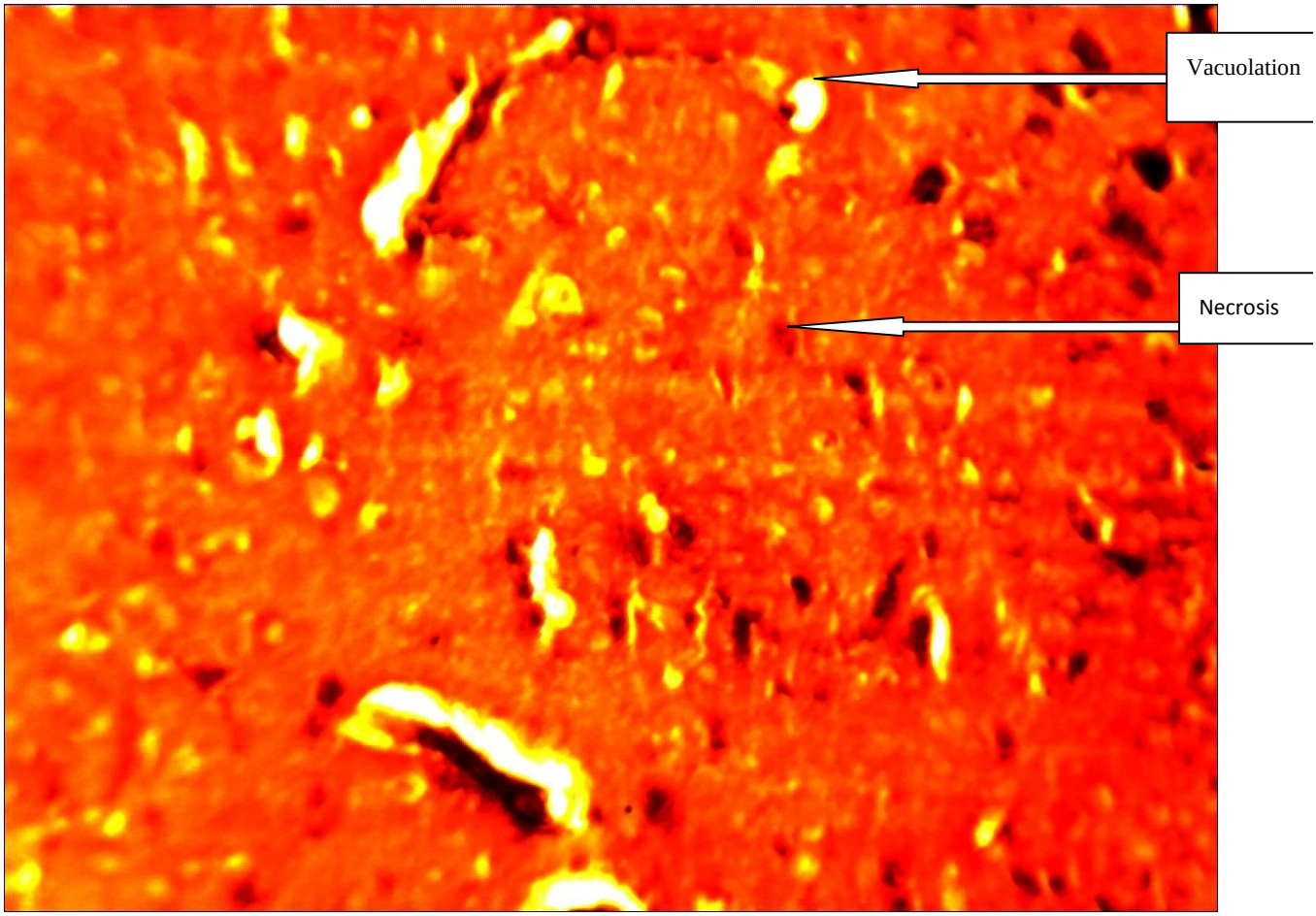

Plate 16. L.S. of neuronal vacuolation and necrosis of the cerbral Cortex of wistar rats of group III .X250

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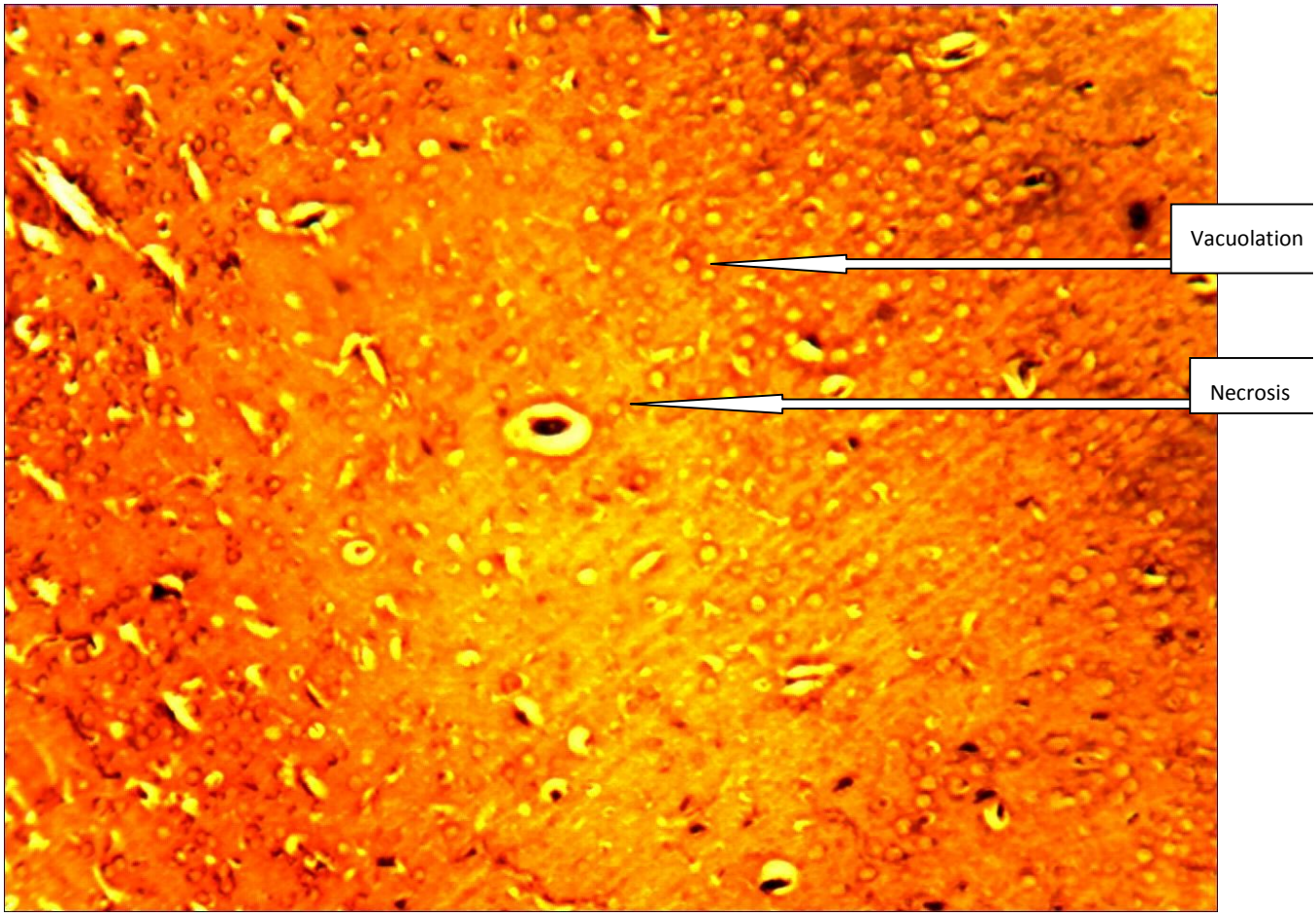

Plate 17.L.S. of neuronal vacuolation and necrosis of the cerbral Cortex of wistar rats of group IV .X100

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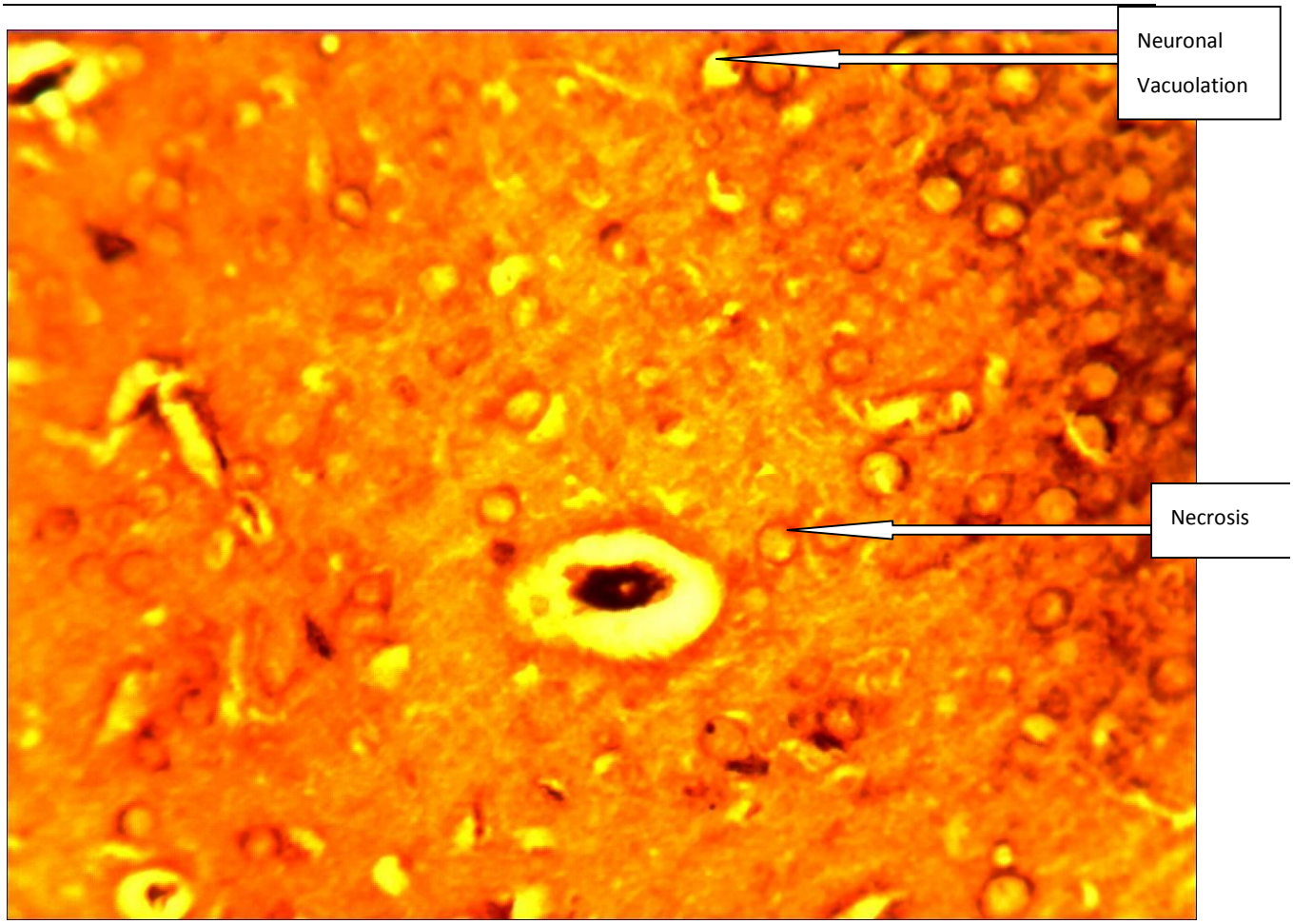

Plate 18. L.S. of neuronal vacuolation and necrosis of the cerbral Cortex of wistar rats of group IV .X250

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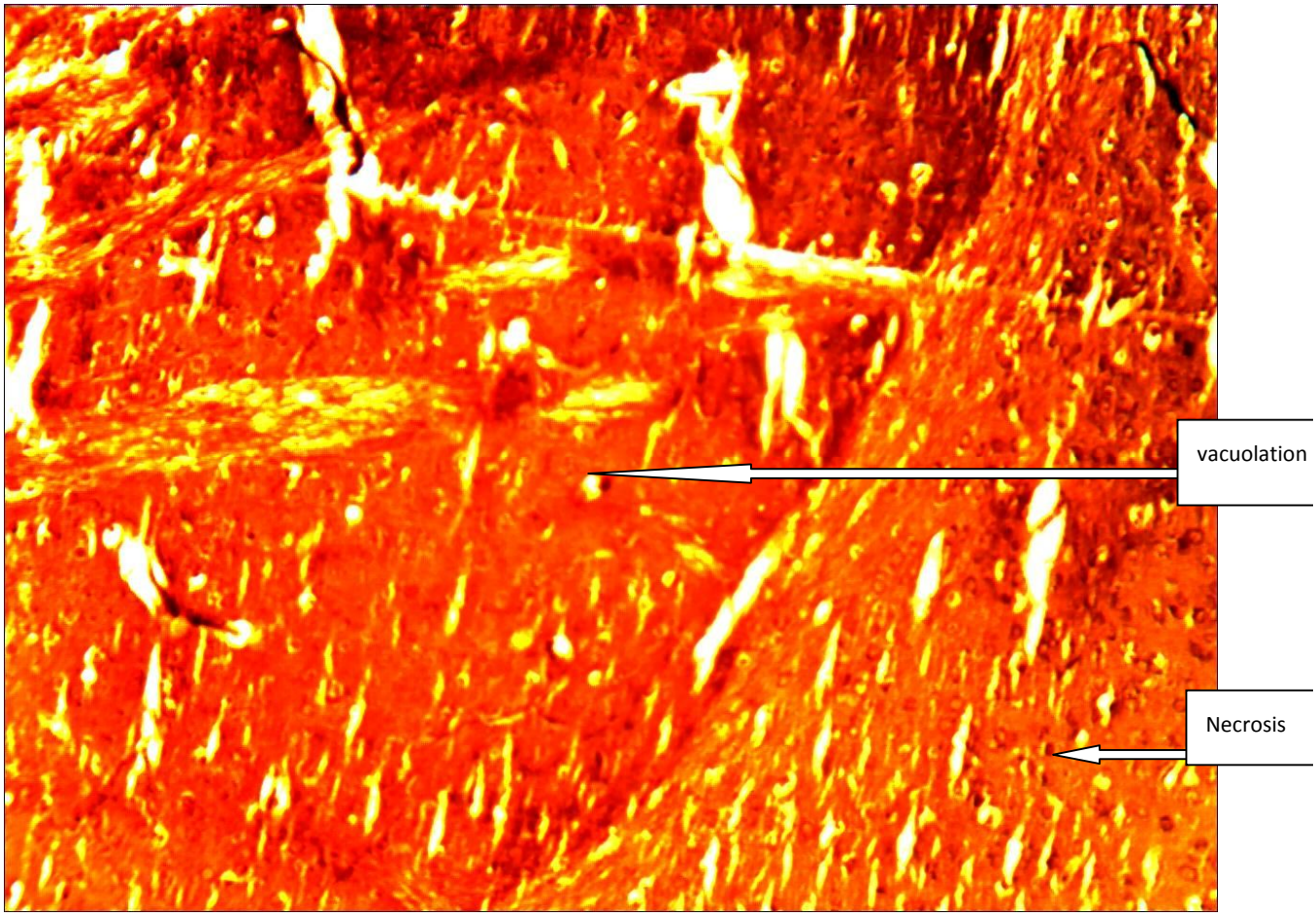

Plate 19. L.S. of extensive neuronal vacuolation and necrosis of the cerbral Cortex of wistar rats of group V .X100

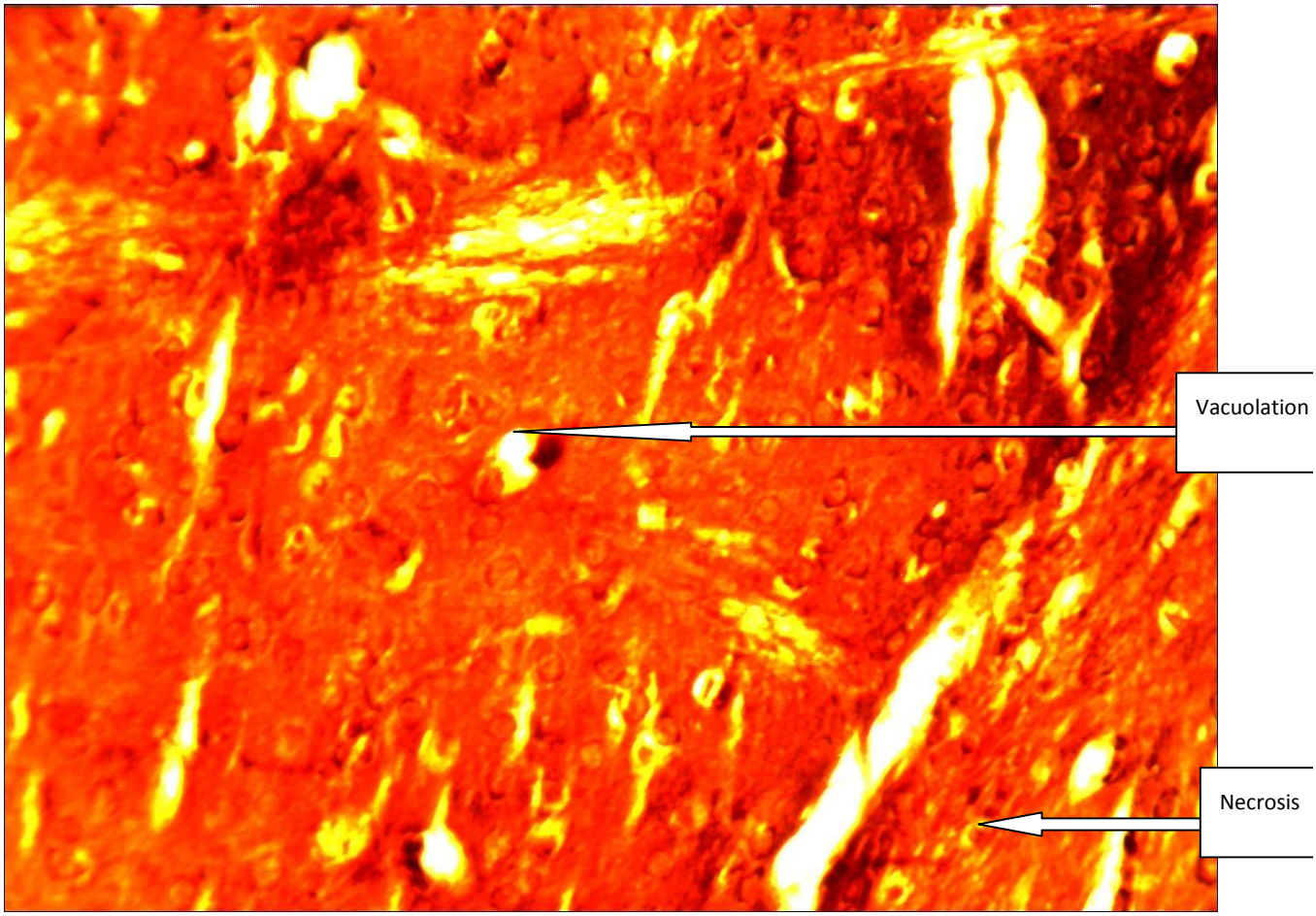

Plate 20.L.S. of extensive neuronal vacuolation and necrosis of the cerebral Cortex of wistar rats of group V .X250

4. Discussion

The cerebral cortex is the key structures of memory formation. It also integrates higher mental functions, general movement, visceral functions, and behavioral reactions. (Brodal, 1977; Cauller, 1995).

Aluminium was said to have contributed to a variety of cognitive impairments in mice, rabbits, and rat pups (Muller et al., 1990; Yokel, 1985, Bilkei-Gorzo, 1993; Mari, 2001). Behavioural impairment has also been reported in wistar rats exposed to soluble aluminium salts (chloride) in the drinking water (Buraimoh et al., 2011b).Both rats (Connor et al., 1988) and mice (Yen-Koo, 1992) have demonstrated such impairments at doses exceeding 200 mg of aluminium per kg of body weight per day. Although significant alterations in acquisition and retention of learned behaviour were documented, the possible role of organ damage (kidney, liver, immunological) due to aluminium was incompletely evaluated in these studies (WHO, 1997).

Studies on workers exposed to Al dust in industrial environments demonstrate similar effects (Rifat, et al., 1990; Bast-pettersen, et al., 1994; White et al., 1992, Akila et al., 1999). Many researchers have found elevated Al levels to be associated with a decline in visual memory,

attention, concentration, frontal lobe function and lower vocabulary scores in hemodialysis patients (Bolla et al., 1992). Aluminium chloride was said to have negative effects on anxiety-related behaviour of wistar rats as indicated by increased rate of anxiety in Aluminium treated rats (Buraimoh, et al., 2011c).Although, other reports on occupational Al exposure and neurological impairments demonstrate mixed findings (Sim et al., 1997). Despite strong experimental and clinical evidence for Al neurotoxicity, the mechanism of Al effects on the nervous system is still not completely clear.

In our present study, sections of the cerebral cortex were prepared from control and Al-exposed wistar rats and the effects of Al exposure on the cerebral cortex were histologically examined in order to describe any observed changes. A variety of histological changes were observed in the cerebral cortex of Aluminum exposed groups when compared with the control (Plates 1-20).

This research work has demonstrated that wistar rats exposure to aluminium chloride for a duration of eight weeks resulted into neuronal vacuolation and necrosis of the cerebral cortex which are form of neuro-degeneration (See Plates 3-10&13-20). We also observed extensive neuronal vacuolation and necrosis in the highest dose Aluminium treated groups (plates 9-10&plates 19-20). Since the Cerebral Cortex is said to play a key role in memory, attention, perceptual awareness, thought, language, and consciousness, then the neuro-degeneration (extensive vacuolation and necrosis) observed in the histology of the cerebral cortex of adult wistar rats could go a long way in affecting these functions(memory, attention, perceptual awareness, thought, language, consciousness, etc).

5. Conclusion

Our observations revealed that at higher dose exposure, extensive neuronal vacuolation and necrosis of cerebral cortex was evident, indicating loss of nissl substances. Mild vacuolar changes occur with empty spaces appear probably due to increased concentration of Aluminium toxicity. Based on our observation, we therefore conclude that Aluminium chloride exposure has neurodegenerative effects on the histology of cerebral cortex of adult wistar rats especially at higher dose. Therefore, caution should be taken in its usage.

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