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Neurophysiology in Fish in Relation to Pain

by

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ILAB

A Research and Development Laboratory in Aquaculture



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ILAB

located

at

THE HIGH-TECHNOLOGY CENTER IN BERGEN



ILAB's Aqua laboratory facilities are located at the ground floor and comprises 2.300 m²



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The Aqua Labs



AQUA LABS

- Temp 4-30 °C
- Salinity 0-34 ppm



DISEASE LABS

- Strict sanitary barriers



GLP-REGISTERED LAB

- Vaccine testing



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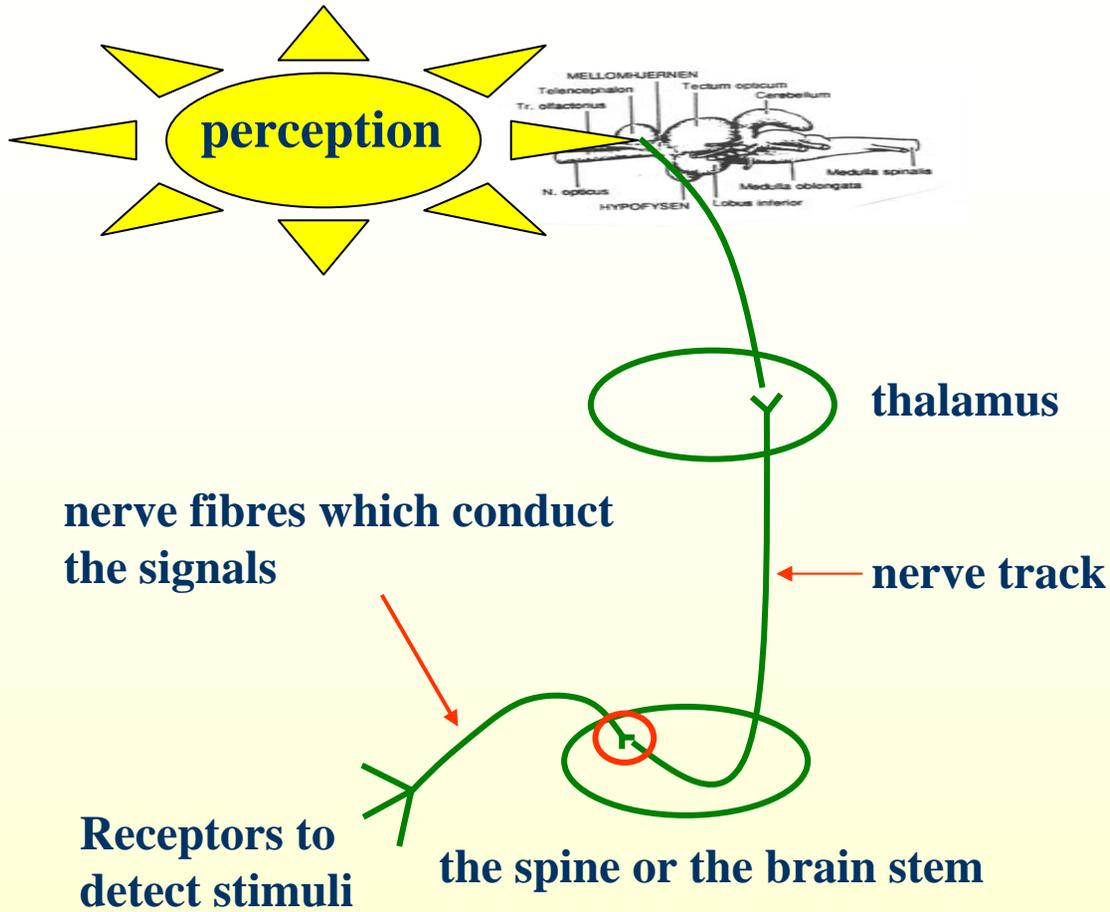
ILAB's animal unit and fish welfare



Jan Ove Wedaa assists one of our customers in vaccination of fish



From one of ILAB's fish tanks showing a tiny catfish

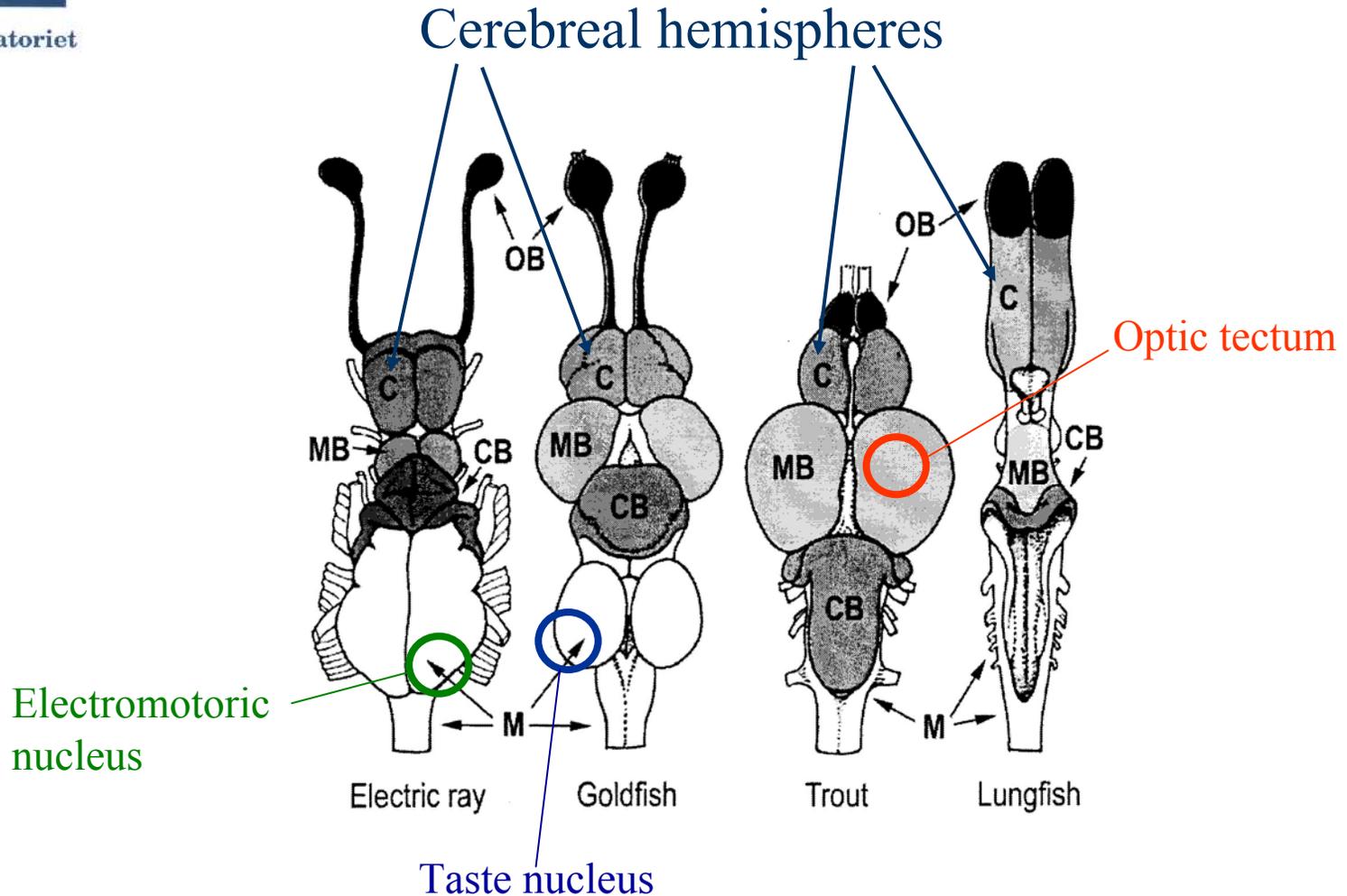


Perception and neurophysiology



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Specialised brain structures



Comparison of brain structure in four fish species (Roose, 2002)



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Do these fish suffer?



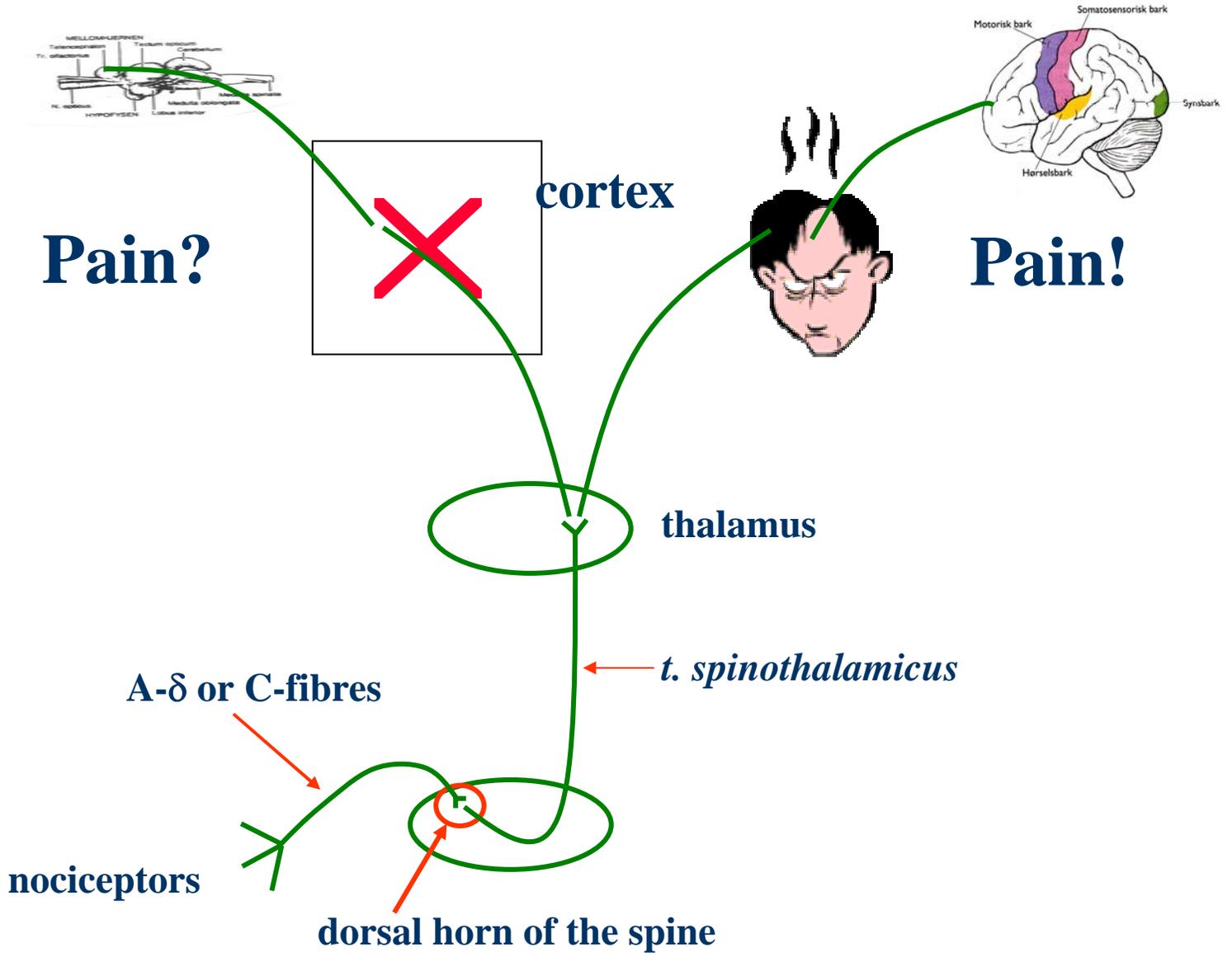
Salmon crowded before being pumped into the anaesthesia tank



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What's Nociception?

- **Nociception is the simple detection of a noxious, potentially painful stimulus and the reflex response to this**
- **It might not induce pain**



The main nociceptive system in vertebrates

Nociceptors – Specialised Receptors

- **Able to detect potential tissue damaging stimuli**
- **High threshold**
- **Need no special morphology**
- **Necessary for avert reactions**
- **Found in a form in all animals with nervous system**
- **Not sufficient for pain perception**
- **Pain perception must be interpreted by the nervous system**

Definition of Pain

- **From the International Association for the Study of Pain:**
- **“An unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage”**



Interpretation

STIMULUS → **PAIN**

STIMULUS → **PAIN**

~~**STIMULUS**~~ → **PAIN**



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Nociception \neq Pain

- **Defined this way pain is a subjective experience and should as such be distinguished from nociception which refers to activity in specialized receptors and pathways**

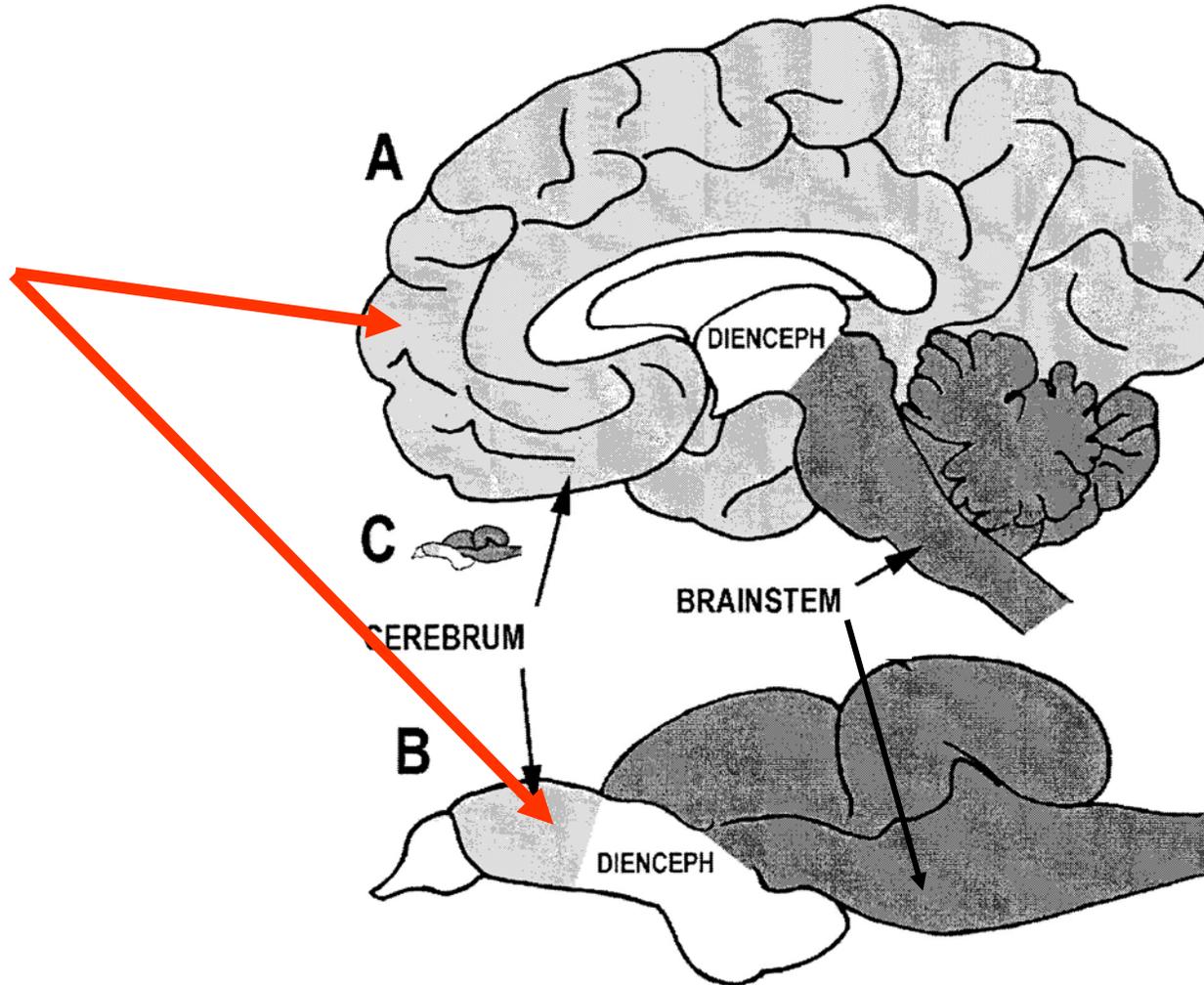
Animal Pain Definition

- **Pain in animals is an adverse sensory experience that is caused by a stimulus that can or potentially could cause tissue damage**
- **This experience should elicit protective motor and vegetative reactions and also have an adverse effect on the animals general behaviour**

Fish Pain Definition

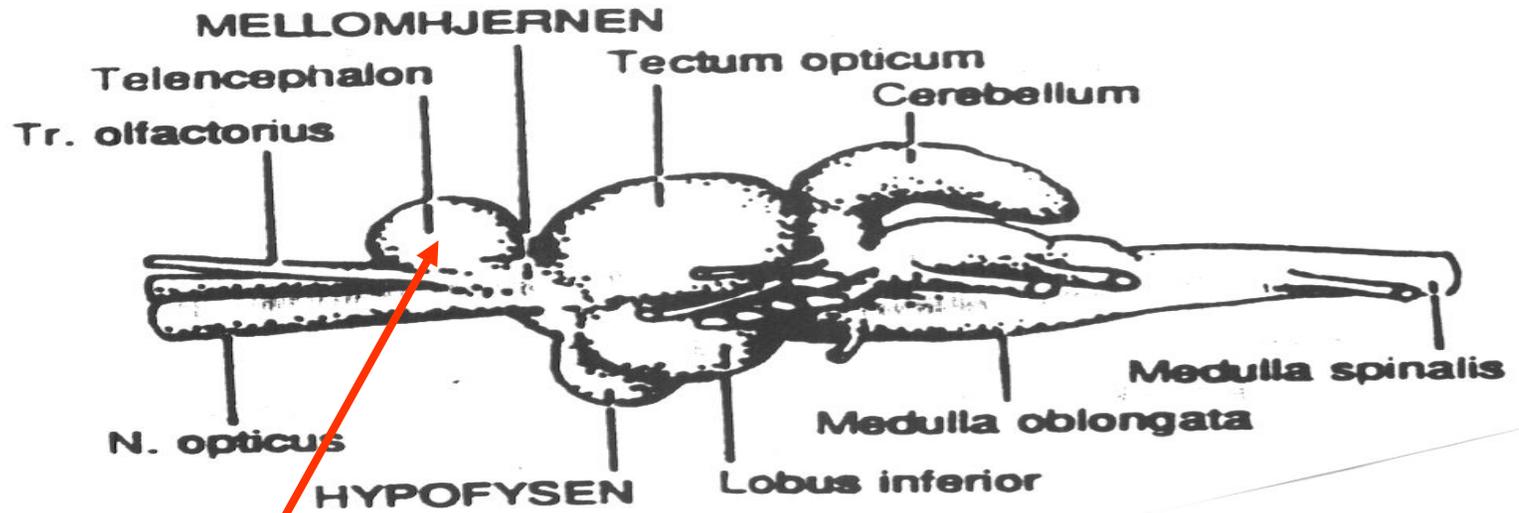
- **Criteria defining fish pain?**
- **Different from nociception?**

Brain and Pain



Comparison of human brain with a trout brain (Roose, 2002)

Cod brain with *telencephalon*

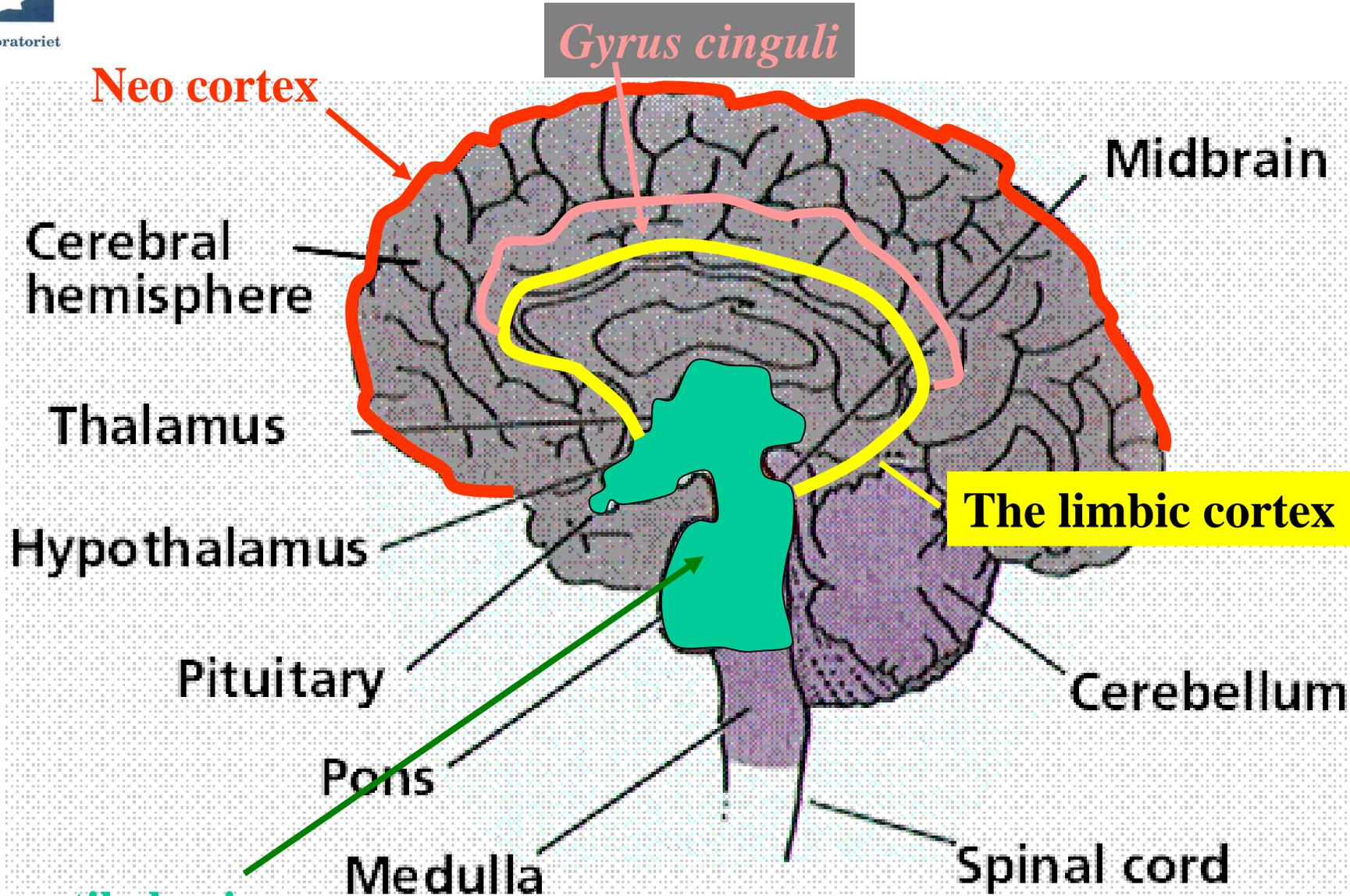


Telencephalon in fish might have the capacity to register and perceive nociceptive information



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Where are feelings located ?

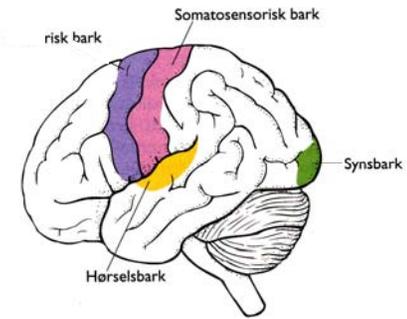
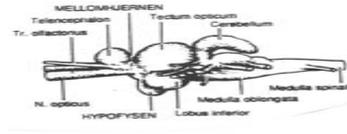




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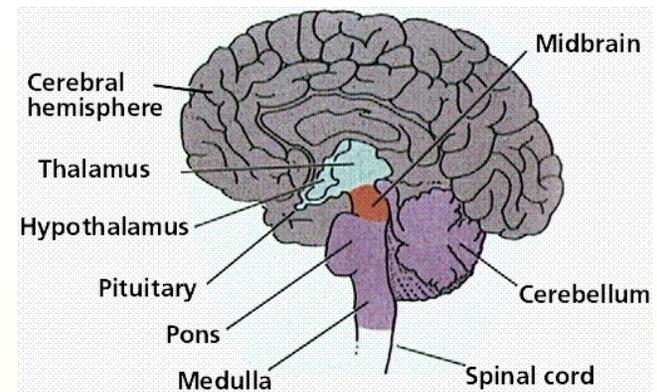
Pain in Fish Recent Scientific Reports

- **Braithwaite, V.A.** & Huntingford, F.A. (2004) Fish and welfare: Do fish have the capacity for pain perception and suffering. *Animal Welfare*, **13**, 87-92
- **Chandroo, K.P.**, Duncan, I.J.H. & Moccia, R.D. (2004a) Can fish suffer?: perspectives on sentience, pain, fear and stress. *Applies Animal Behaviour Science*, **86**, 225-250.
- **Chandroo, K.P.**, Yue, S. & Moccia, R.D. (2004b) An evaluation of current perspectives on consciousness and pain in fishes. *Fish and Fisheries*, **5**, 281-295.
- **Rose, J.D.** (2002) The neurobehavioral nature of fishes and the question of awareness and pain. *Reviews in Fisheries Science*, **10**, 1-38.
- **Sneddon, L.U.** (2002) Anatomical and electrophysiological analysis of the trigeminal nerve in a teleost fish, *Onchorhynchus mykiss*. *Neuroscience letters*, **319**, 167-171.



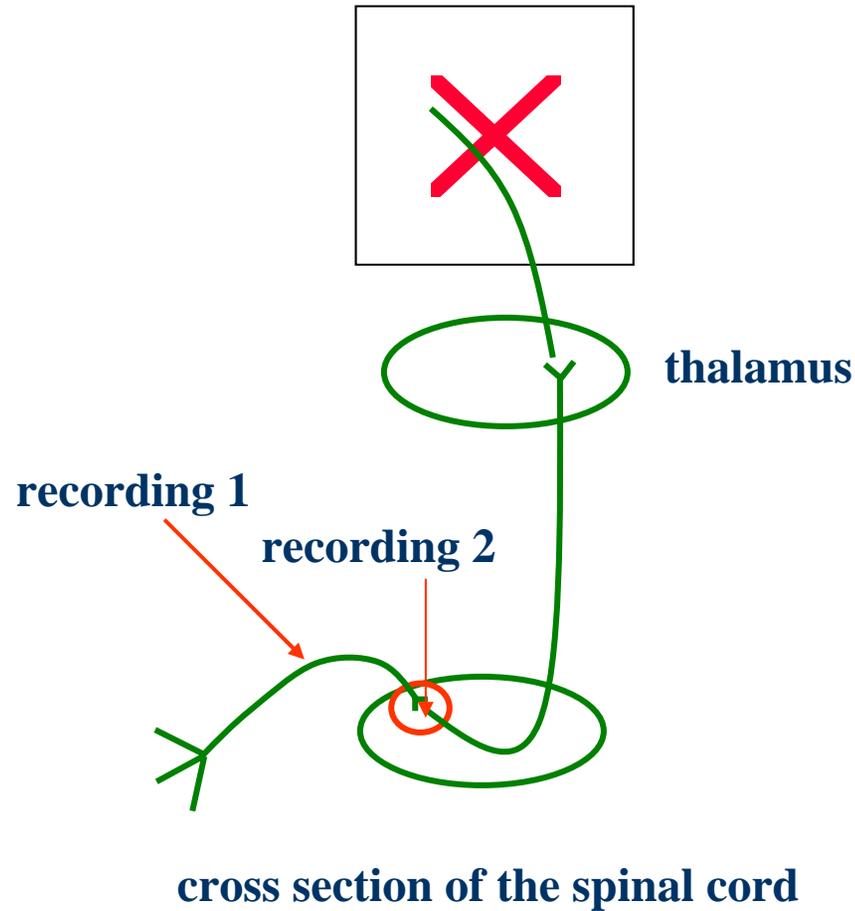
Recent Scientific Reports

- **Sneddon, L.U. (2003a)** The evidence for pain in fish: the use of morphine as an analgesic. *Applied Animal Behaviour Science*, **83**, 153-162.
- **Sneddon, L.U. (2003b)** Trigeminal somatosensory innervation of the head of a teleost fish with particular reference to nociception. *Brain Research*, **972**, 44-52.
- **Sneddon, L.U. (2004a)** Evolution of nociception in vertebrates: comparative analysis of lower vertebrates. *Brain Research Reviews*, **46**, 123-130.
- **Sneddon, L.U. (2004b)** Pain Perception in Fish. *Fish Farmer*, **27**, 8-10.



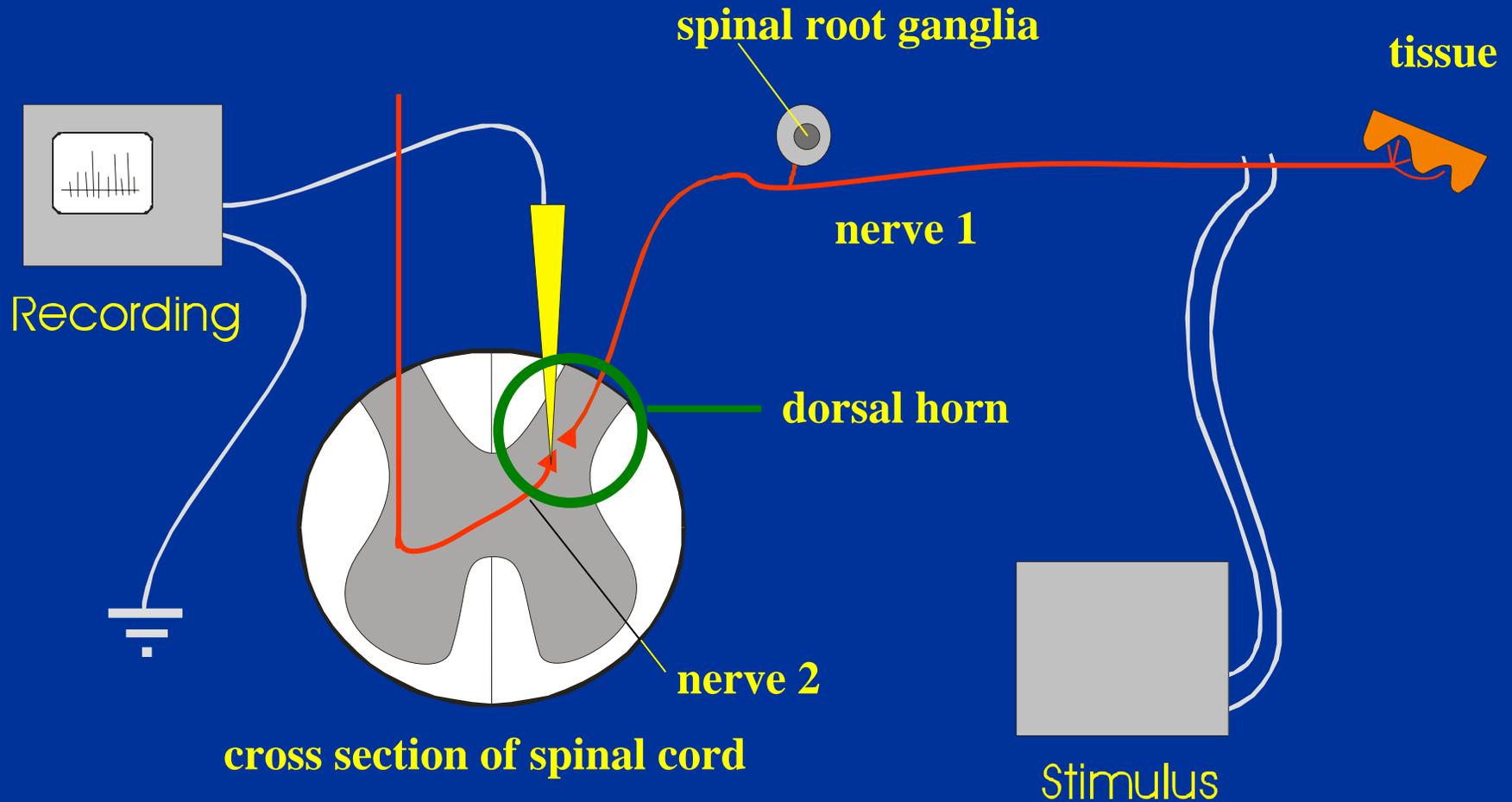
Recent Scientific Reports

- **Sneddon, L.U., Braithwaite, V.A. & Gentle, M.J. (2003a)** Do fishes have nociceptors? Evidence for the evolution of a vertebrate sensory system. *Pros. R. Soc. Lond. B. Biol. Sci.*, **270**, 1115-1121.
- **Sneddon, L.U., Braithwaite, V.A. & Gentle, M.J. (2003b)** Novel Object Test: Examining Nociception and Fear in the rainbow Trout. *The Journal of Pain*, **4**, 431-440.
- **Sohlberg, S., Meidell, C. & Søli, N.E. (2004)** Oppfatter fisk smerte, frykt og ubehag? En litteraturgjennomgang. *Norsk Veterinærmedisinsk Tidsskrift*, **6**, 429-438

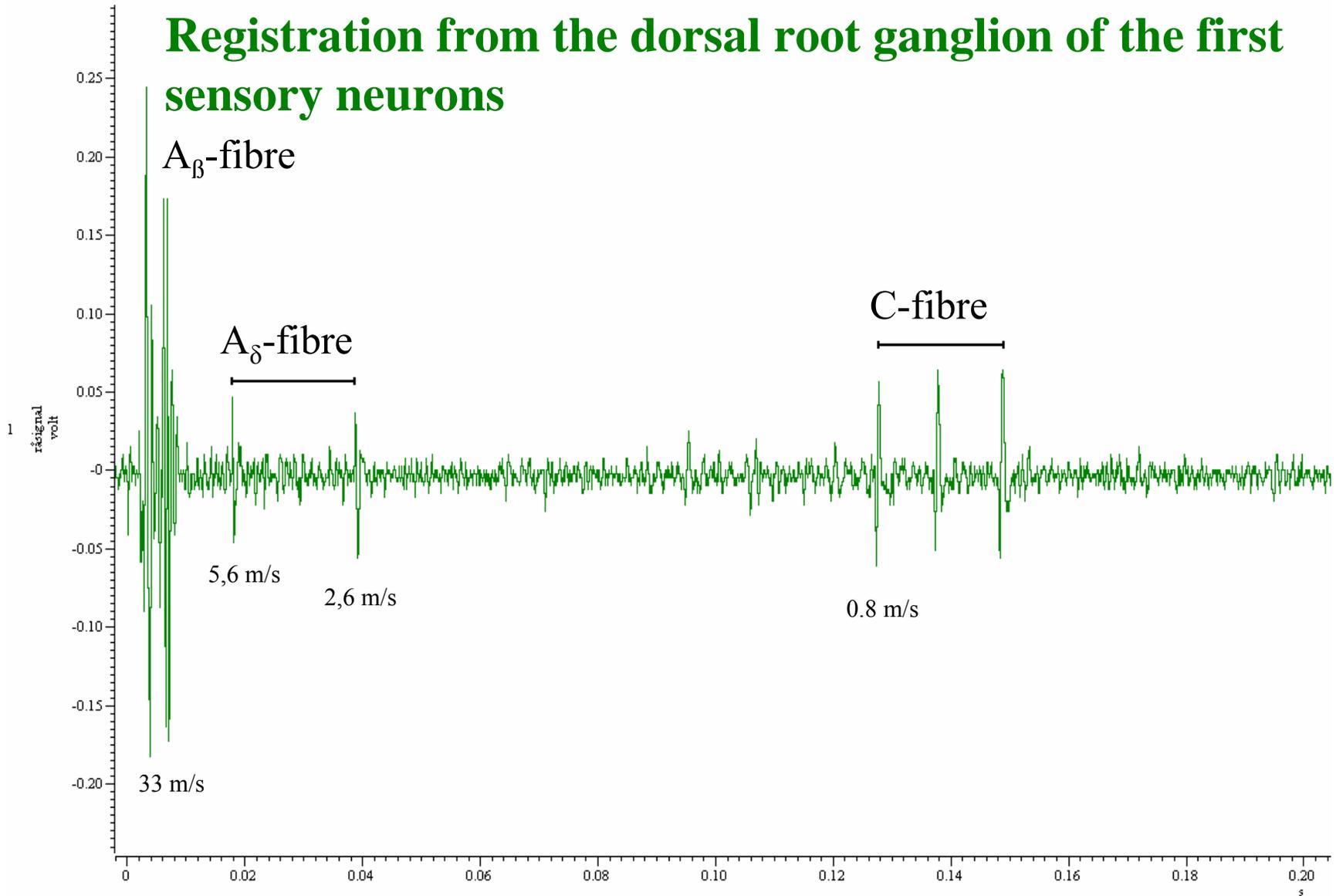


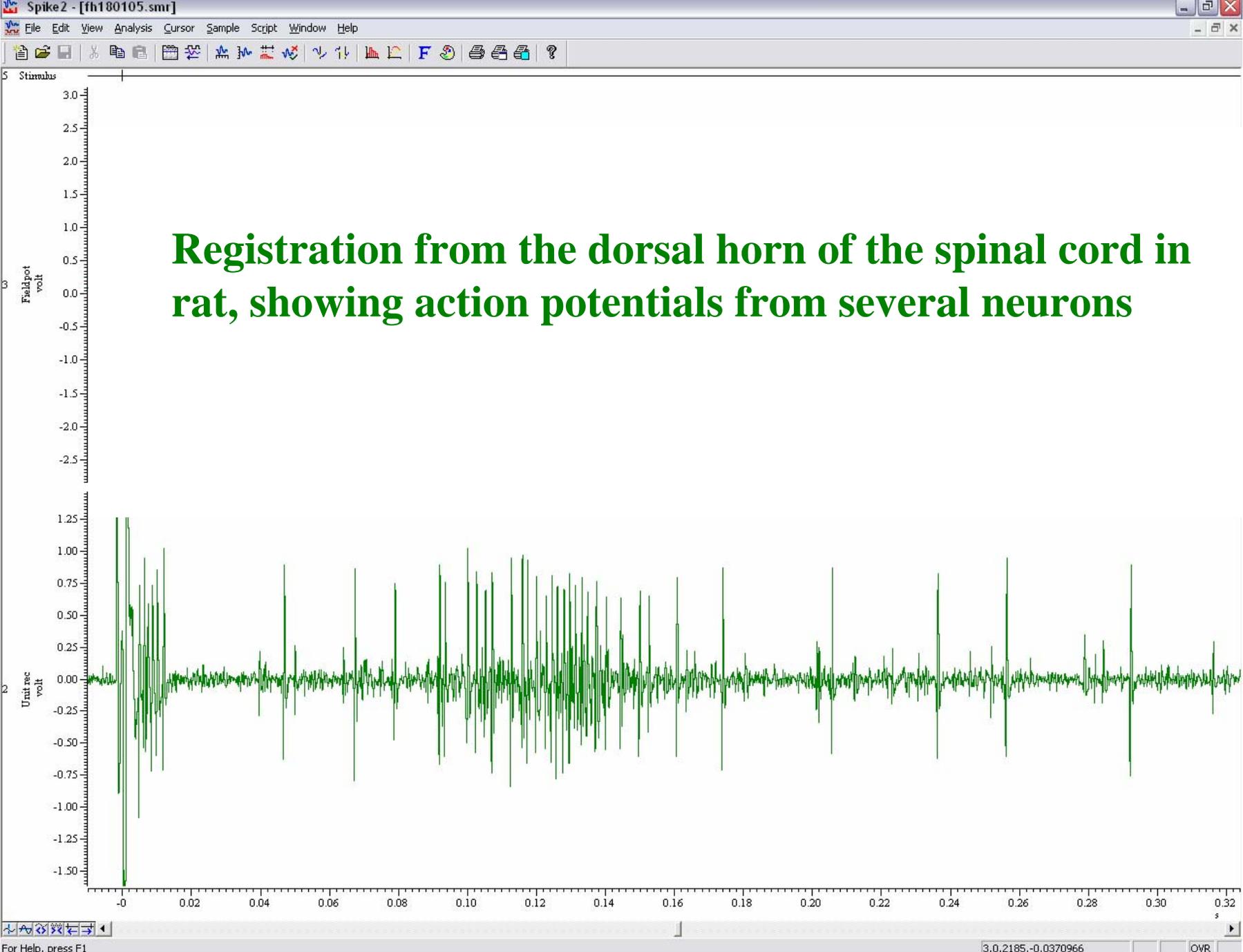
How to record nociceptive information

Levels of information accessible for study



Registration from the dorsal root ganglion of the first sensory neurons





Registration from the dorsal horn of the spinal cord in rat, showing action potentials from several neurons

Recording from the trigeminal nerve in fish

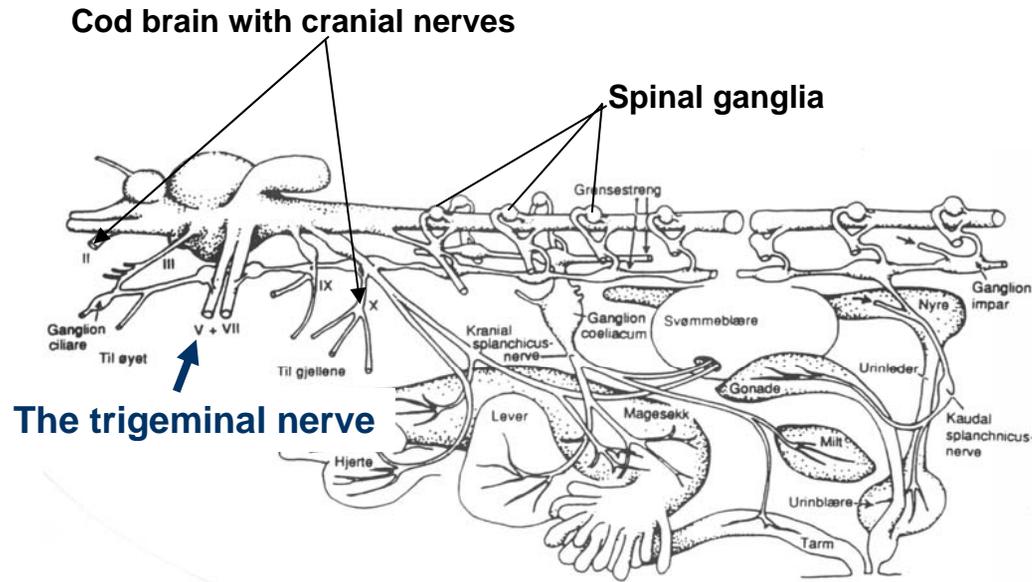
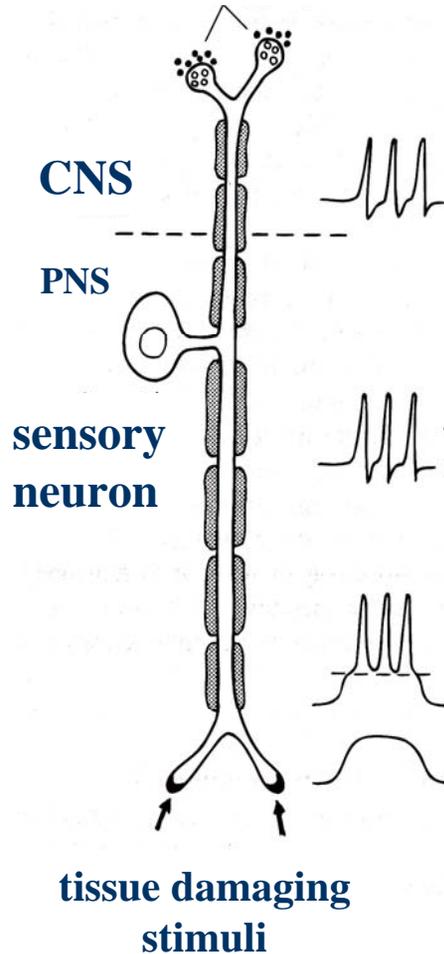


Figure: Cod brain with cranial nerves and the spinal nerves (*Nilsson et al 1983*). In rainbow trout Sneddon has recorded action potentials from the trigeminal ganglion and the nociceptors identified have similar physiological properties as nociceptors found in higher vertebrates.

Fish Do Have Nociceptors

neurotransmitters

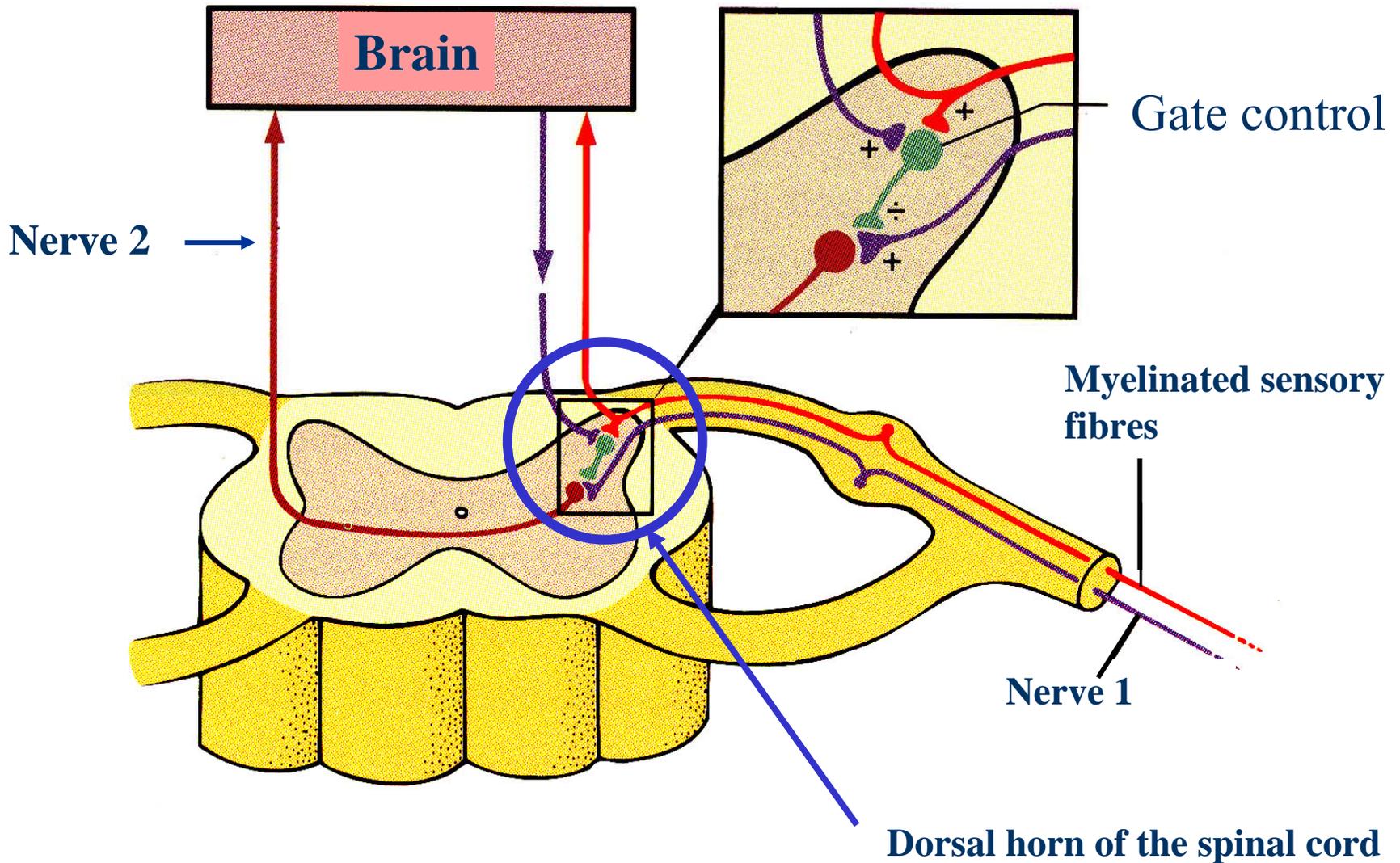


- **Anatomical and physiological studies have confirmed the existence of both A- δ and C-nociceptor fibres in rainbow trout (Sneddon, 2002; Sneddon *et al* 2003)**

Brain of Haddock



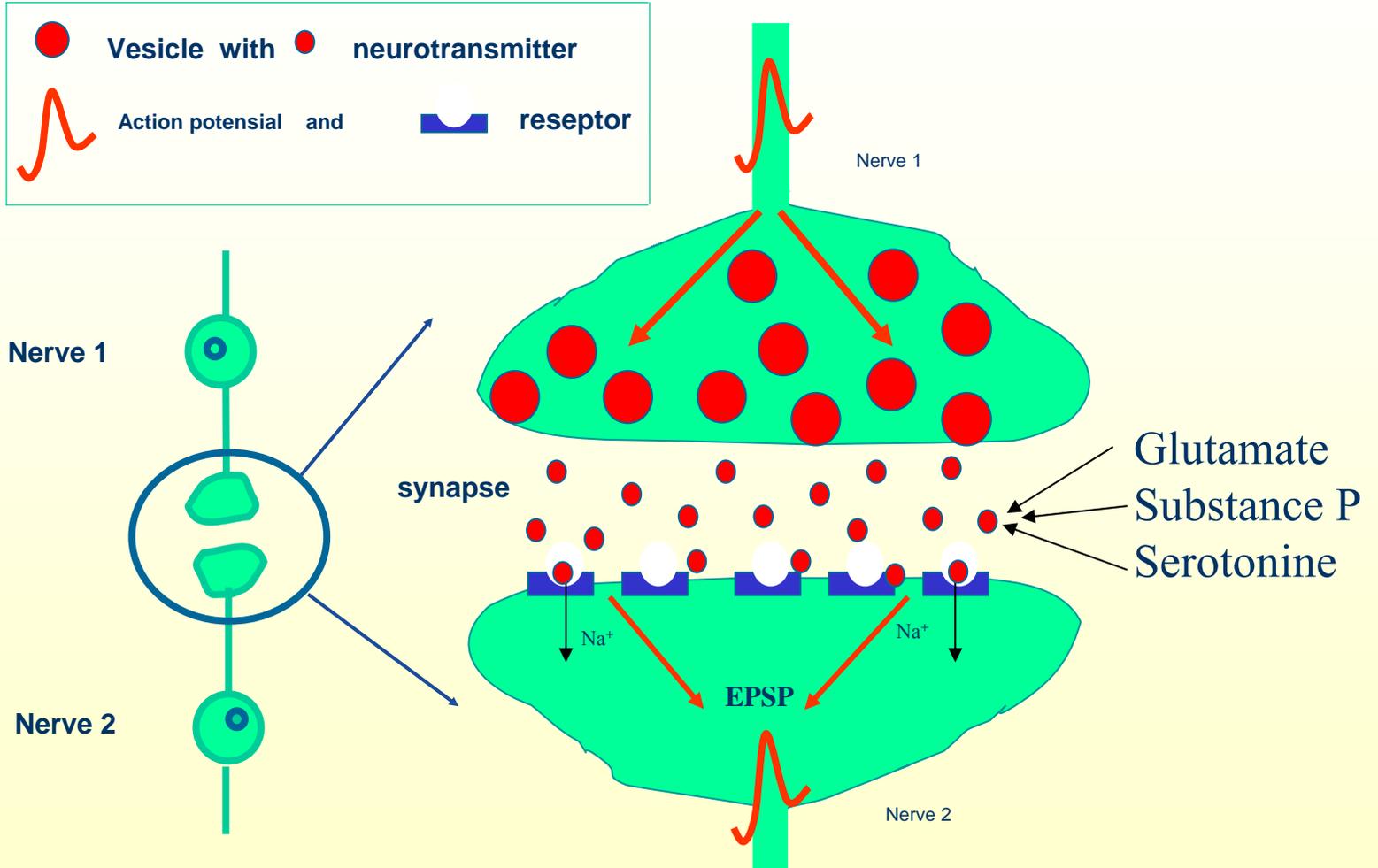
No segmental control in fish?





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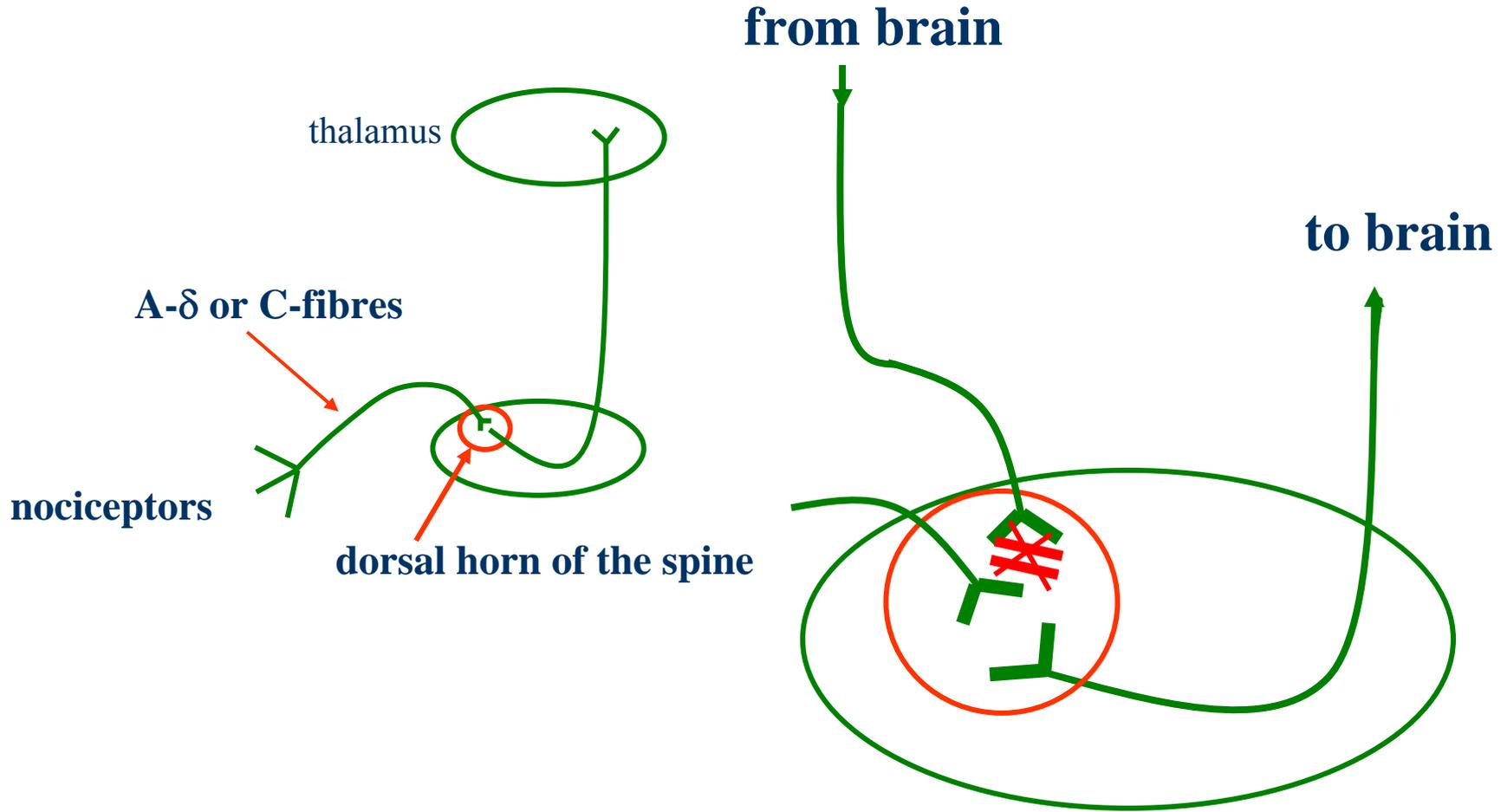
Fish have Transmitter Molecules



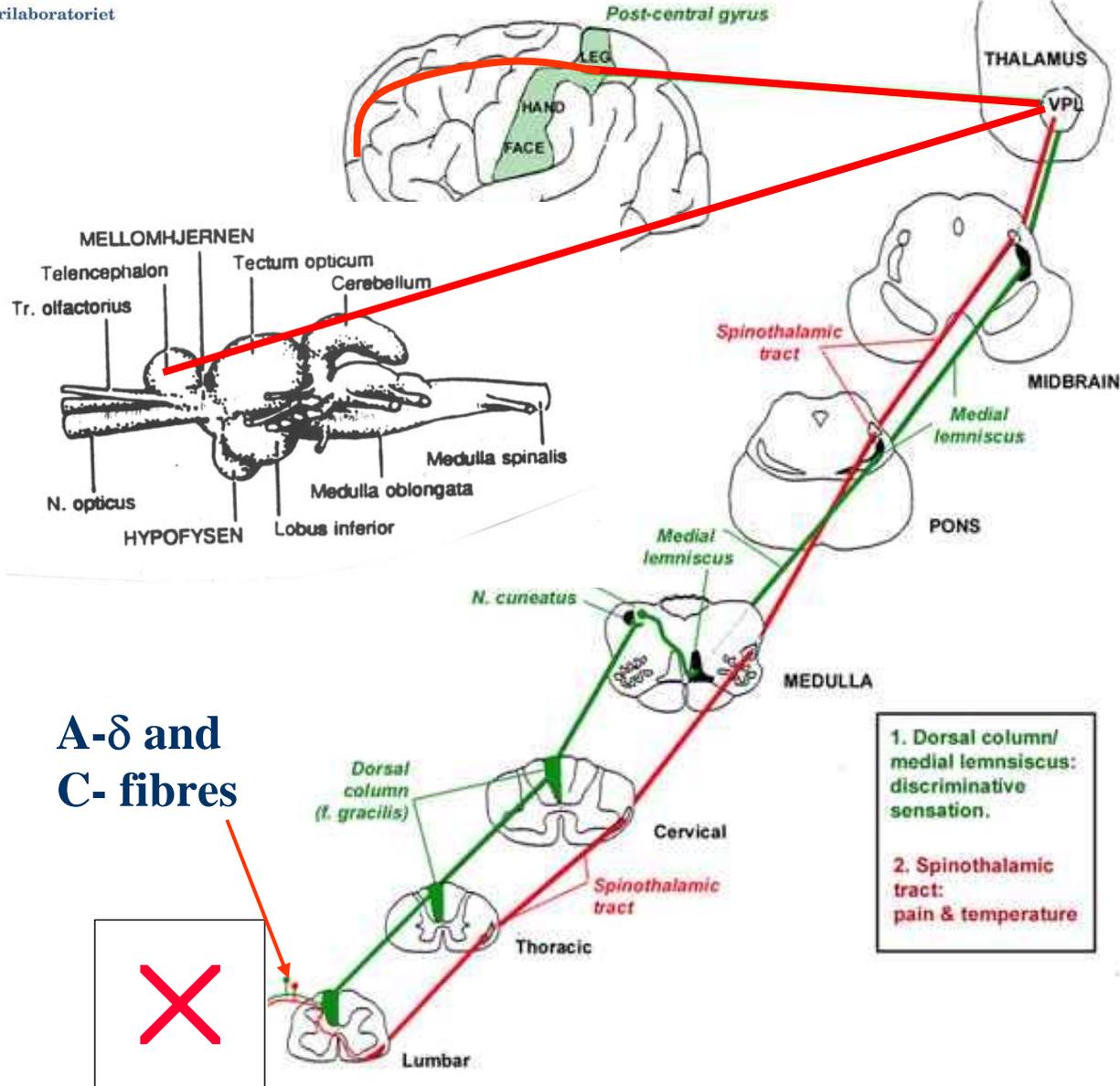


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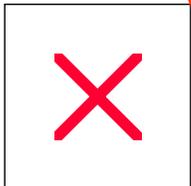
Does morphine reduce pain in fish?



The Neuronal Pathway



A- δ and C- fibres



Fish Consciousness?

- **Whether or not the nervous system of fish permits consciousness, from a purely neurobiological perspective, remains a very open question (Chandaroo *et al* 2004)**

Subcortical Perception

- **There is considerable evidence that sensory stimuli are perceived in the absence of the cerebral cortex**
- **This is especially true for pain**
- **The cortical receiving areas are apparently concerned with the discriminative, exact, and meaningful interpretation of pain, but perception alone does not require the cortex**
- **These statements are quoted from William Ganong (1989) Review of Medical Physiology**

Conclusion

- Nociceptive systems have been identified in several fish species including rainbow trout
- Further research should be done in order to examine if fish used in research and common farmed species have a nociceptive system

Conclusion

- Fish probably perceive fish pain, but do not feel pain the way we do
- In order to answer if fish can experience pain, still more behaviour studies have to be done