# Voluntary Movements

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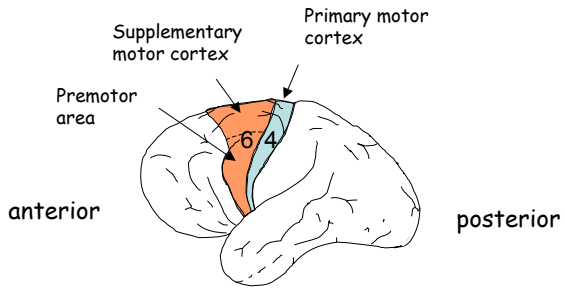
## Cortical areas involved in voluntary movement

- Primary motor cortex (M1, also called Brodmann's area 4)
- Premotor cortex
- Supplementary motor cortex

} area 6

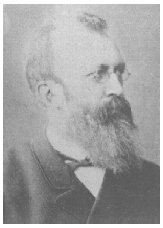


# How are these motor areas discovered?

- Discovered in 1870 by Fritsch and Hitzig - electrical stimulation of different parts of the frontal lobe produces movements of muscles.

  - low stimulation, simple movement, opposite side, primary motor cortex
  - high stimulation, complex movement, bilaterally, premotor and supplementary motor cortex

DR. GYSTAV.T. FRITSCH

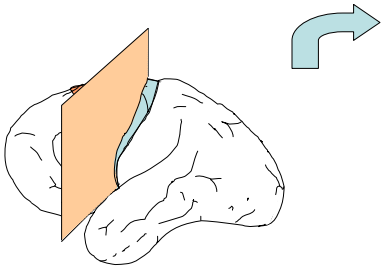


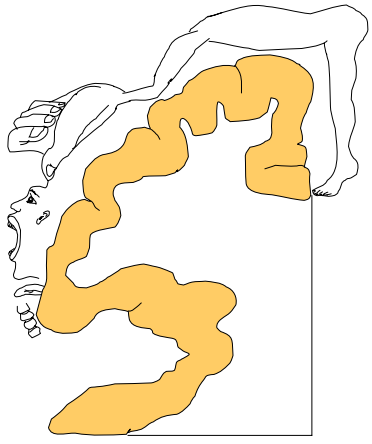
DR. EDUARD HITZIG



# A somatotopic map of human motor cortex

•1930s-1950s, Canadian neurosurgeon Wilder Penfield used this methods to map the cortex of neurosurgical patients – orderly map of the body on the cortex, the somatotopic organization of the cortex.

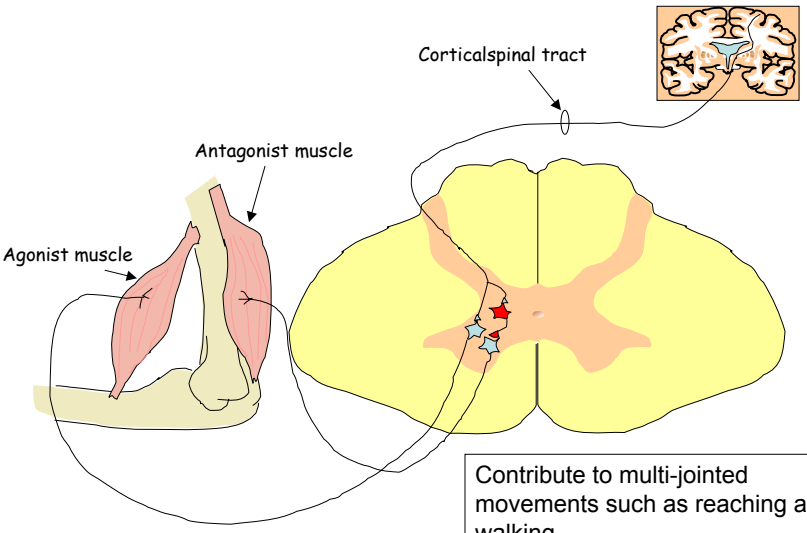




Topographical

Muscle groups control fine movements have bigger areas of representation - distal muscles

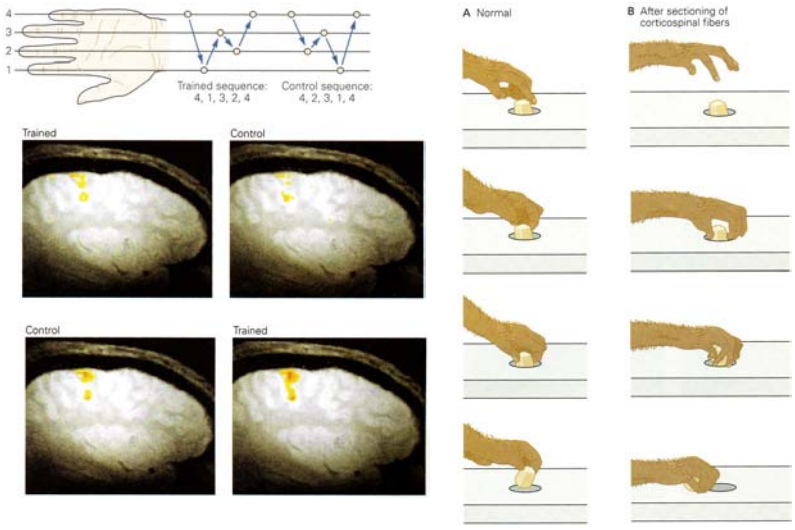
## Corticospinal tract influence spinal motor neurons through direct and indirect connections



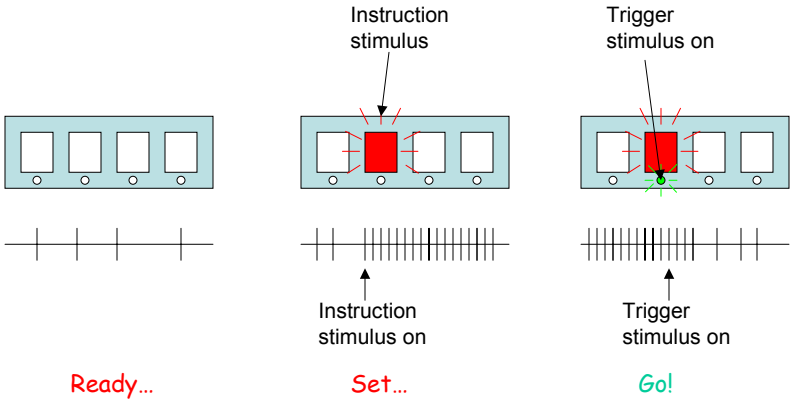

Contribute to multi-jointed movements such as reaching and walking



## Fine control of the digits requires primary motor cortex

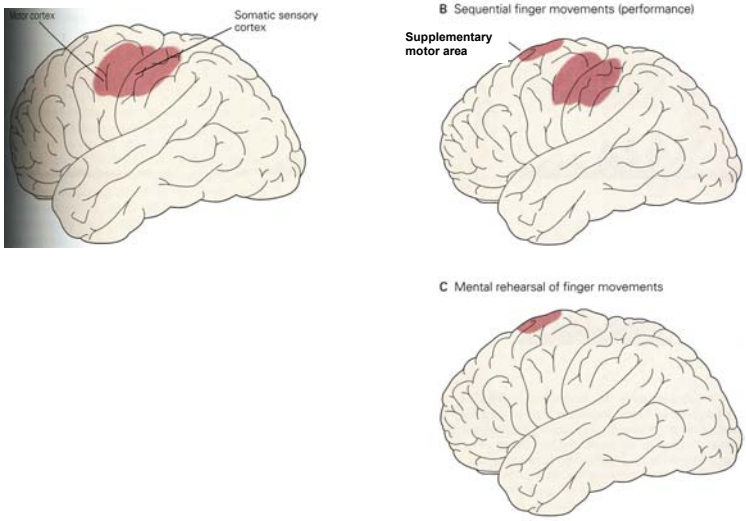


# The lateral premotor areas contribute to the selection of action and to sensorimotor transformations

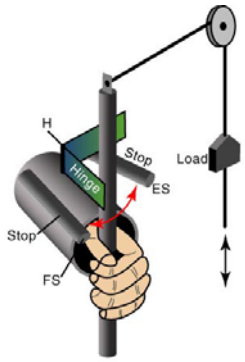




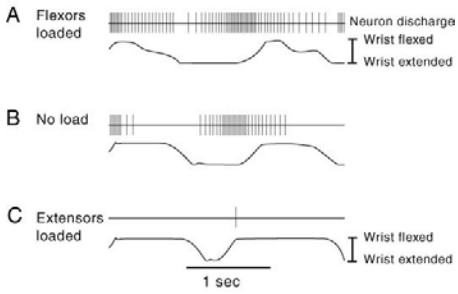

# Supplementary motor cortex are activated during complex and imagined movements



# M1 neuron controls movement




Evarts group, 1968

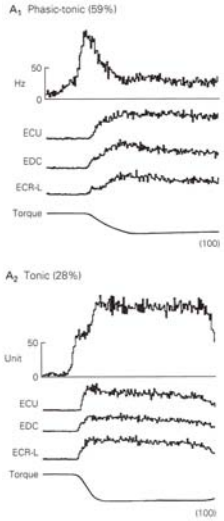


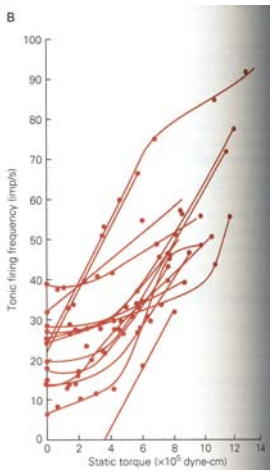

Neuron discharge starts several hundred millisecond before movement.

Discharge frequency changed systematically in temporal relation to either flexion or extension.



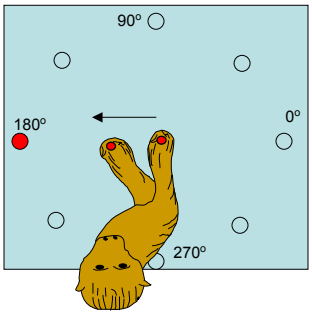
# Direct relationship between the firing rate of motor cortical neurons and force generation

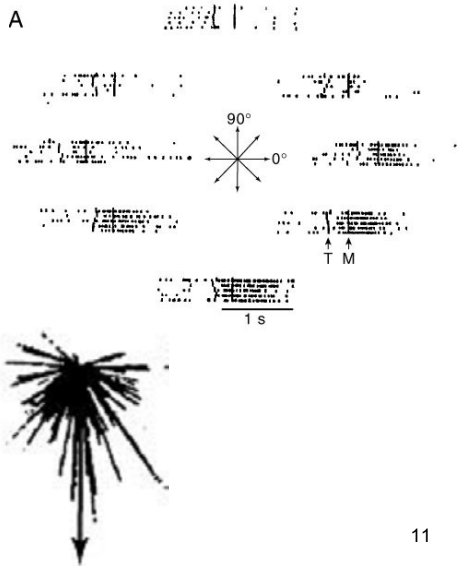


# Individual M1 neuron fire preferentially in connection with movement in certain direction.

Georgopoulos et al., 1982

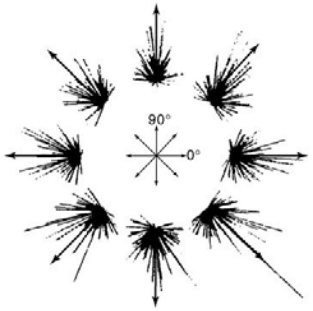



Different cells have different preferred movement directions.



# Direction of movement is encoded in the motor cortex by the pattern of activity in an entire population of cells




M1 cortical neurons with different preferred directions are all active during movement in a particular direction. The entirety of this activity results in a population vector that closely matches that of the direction of movement.

# Direction vectors and population vectors