Motor Units and Control of Force (W6)

- The nervous system is a monitoring and control system
- Stimulis: internal (food in intestine) or external (visual)
- Response could be directed: internally (void bladder) or externally (move body)
- High level of sophistication needed for control, initiation, planning of movements
- Low level of sophistication needed for muscle substructure (within muscle cells)

Lower (ALPHA) motor neurons (the neurons that directly innervate (supply with nerves) muscle

- Involved in all movement (voluntary and reflexive)
- Directly innervate muscle
- Cell bodies located in spinal cord

Muscle fibres have 2 special properties:
1. They can change length 2. They can generate force

The motor unit and the motor pool

- **Motor unit** = 1 alpha motor neuron + many muscle fibres that it innervates
- Small motor units: <10 muscle fibres (fingers,eyes)
- Large motor units: >1000 muscle fibres (calf)
- **Motor neuron pool** = collection of all alpha motor neurons that innervate a single muscle

Controlling force generation - RATE CODING

- **Force summation** = when responses to individual APs merge
- **Unfused tetanus** = oscillatory force generation
- **Fused tetanus** = smooth force summation
- As AP rate increases in a motor neurone, the amount of force generated over time increases

Controlling force generation - SIZE PRINCIPLE

- For constant APs, the smallest motor and associated muscle fibres are activated first. When AP rate increases, it will recruit larger neurons.
- As more neurons are activated, this leads to more force being generated
- Small and large motor units
- To generate graded force, small motor units are recruited first, followed by larger motor units

Small motor neurons have higher membrane resistance and reach threshold more easily

- Smaller motor neurons = small SA = higher membrane resistance
- Smaller neurons tend to have larger EPSPs
- Ohms Law: Change in V(membrane)=R*I
- Small motor neurons reach spiking threshold more easily

Proportional Control

- **Inverse** relationship between the number of **motor units** in a muscle and their **force generating capacity**
- Many small motor units; progressively fewer large motor units
- we want control for smaller forces, therefore less muscle fibres but more motor units, but for larger forces we want less control so more muscle fibres but less motor units
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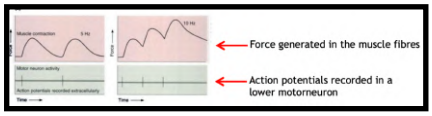
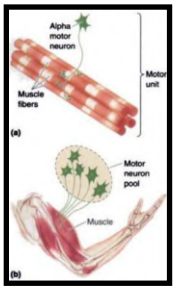




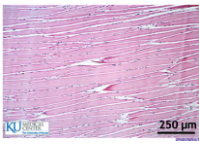
Properties and types of muscle

Properties:
1) Generate force
2) Shorten

Types of muscle:
1) **Skeletal** = striated muscle under voluntary control
2) **Cardiac** = striated muscle under involuntary control
3) **Smooth muscle** = involuntary control

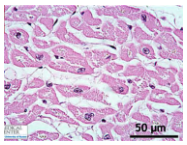
Skeletal muscle contains long, striated fibres

- Each cell has multiple nuclei on periphery of cell body
- Striations and orderly structure
- Cotractions occur in a single direction



Cardiac muscle contains branched, striated fibres

- Usually one central nucleus per muscle fibre
- Striated and unordered structure
- There is no single direction of contraction



Smooth muscle has no striations

- Single nucleus per fibre
- No orderly direction
- The muscle is not under voluntary control

Functional structure of skeletal muscle

- Whole muscle - attached to a bone by a tendon
- Muscle fibre (single muscles cell), myofibril (1-2microngss in diameter
- Myofilaments (thick(myosin) and thin(actin) filaments)

The sarcomere - thick and thin filaments

- The sliding filament model -in each sarcomere, Z-discs are pulled towards the M line
- This leads to either shortening or generation of tension

Actin and Myosin:

- Arranged in a regular hexagonal structure
- 2 actin for every 1 myosin
- Each thick filaments can attach to 6 other thing filaments