Al-Mustaqbal University
Department of Biomedical Engineering

ELECTROMYOGRAPHY (EMG)

Medical Measurements Lab 1
Fourth Stage

Supervised by

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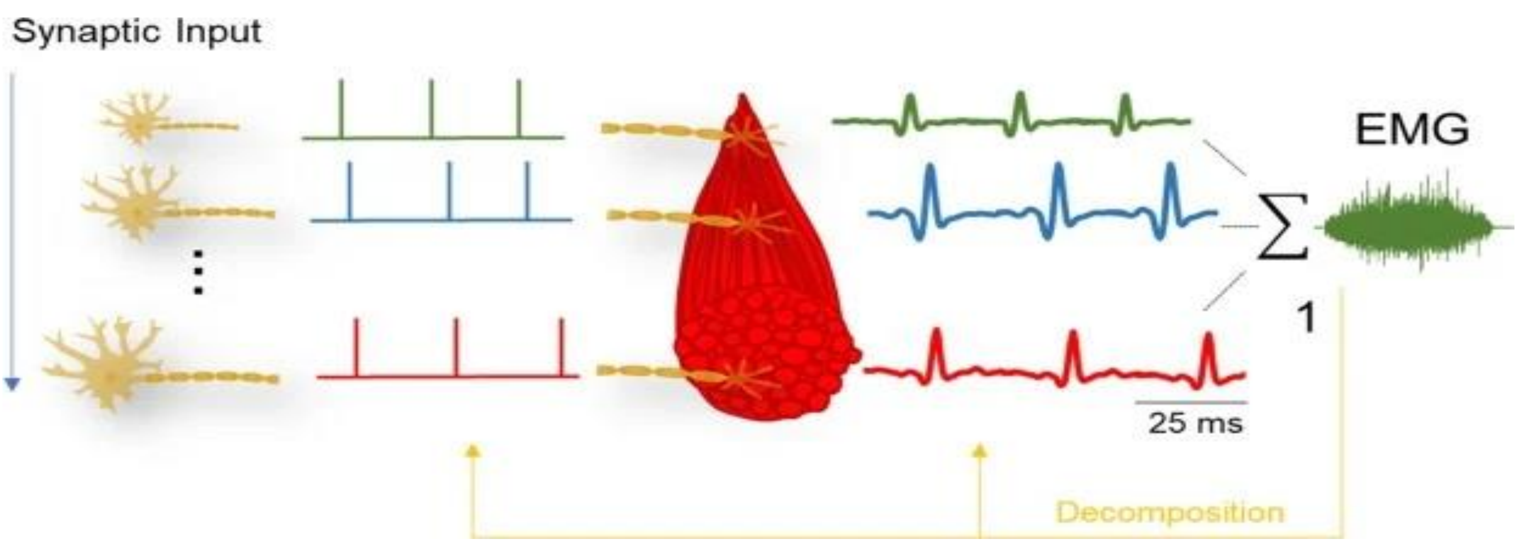
Electromyography (EMG)

- Electromyography (EMG) is a technique used to measure and record the electrical activity produced by skeletal muscles. It’s commonly employed in clinical settings to assess muscle health and function, as well as in research and biofeedback applications.



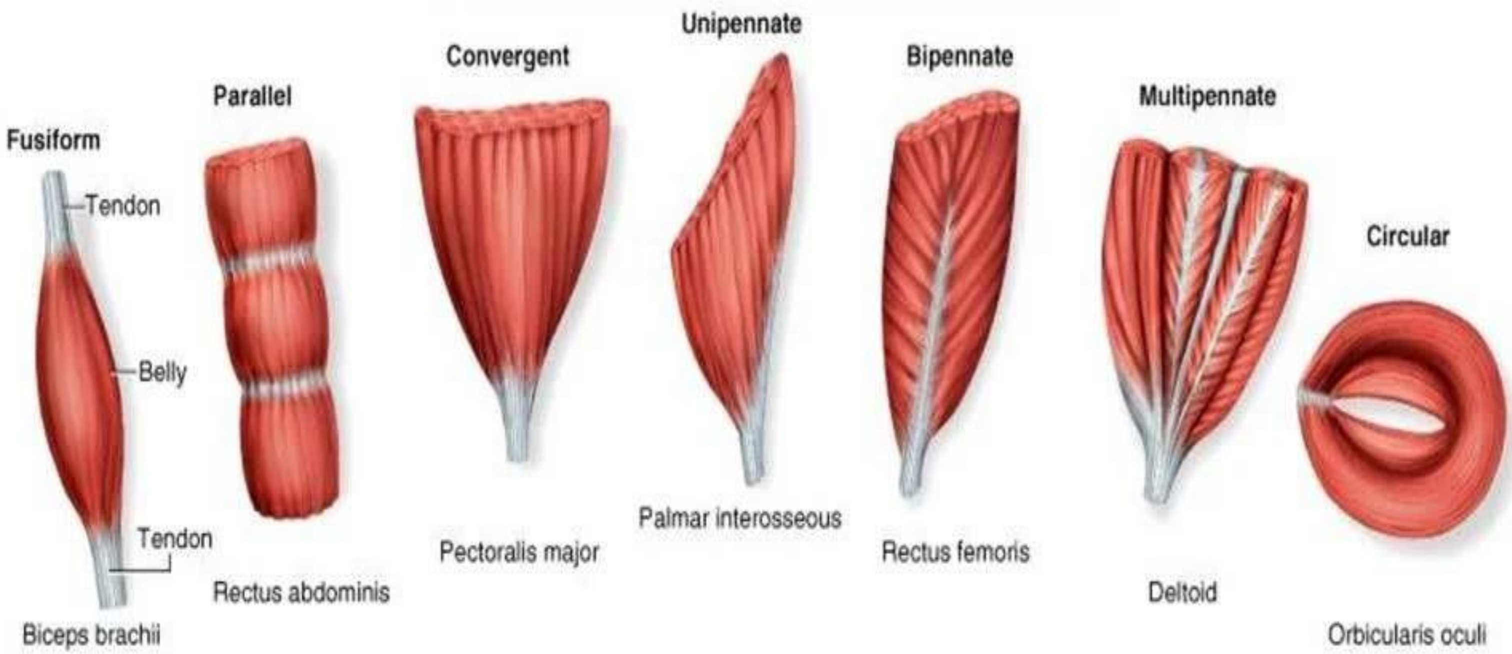
Muscle Types

- **Skeletal muscle,** attached to bones, is responsible for skeletal movements. The peripheral portion of the central nervous system (CNS) controls the skeletal muscles
- **Smooth muscle**, found in the walls of the hollow internal organs such as blood vessels, the gastrointestinal tract, bladder, and uterus, is under control of the autonomic nervous system.
- **Cardiac muscle**, found in the walls of the heart, is also under control of the autonomic nervous system. The cardiac muscle cell has one central nucleus, like smooth muscle, but it also is striated, like skeletal muscle

Properties of Skeletal Muscle

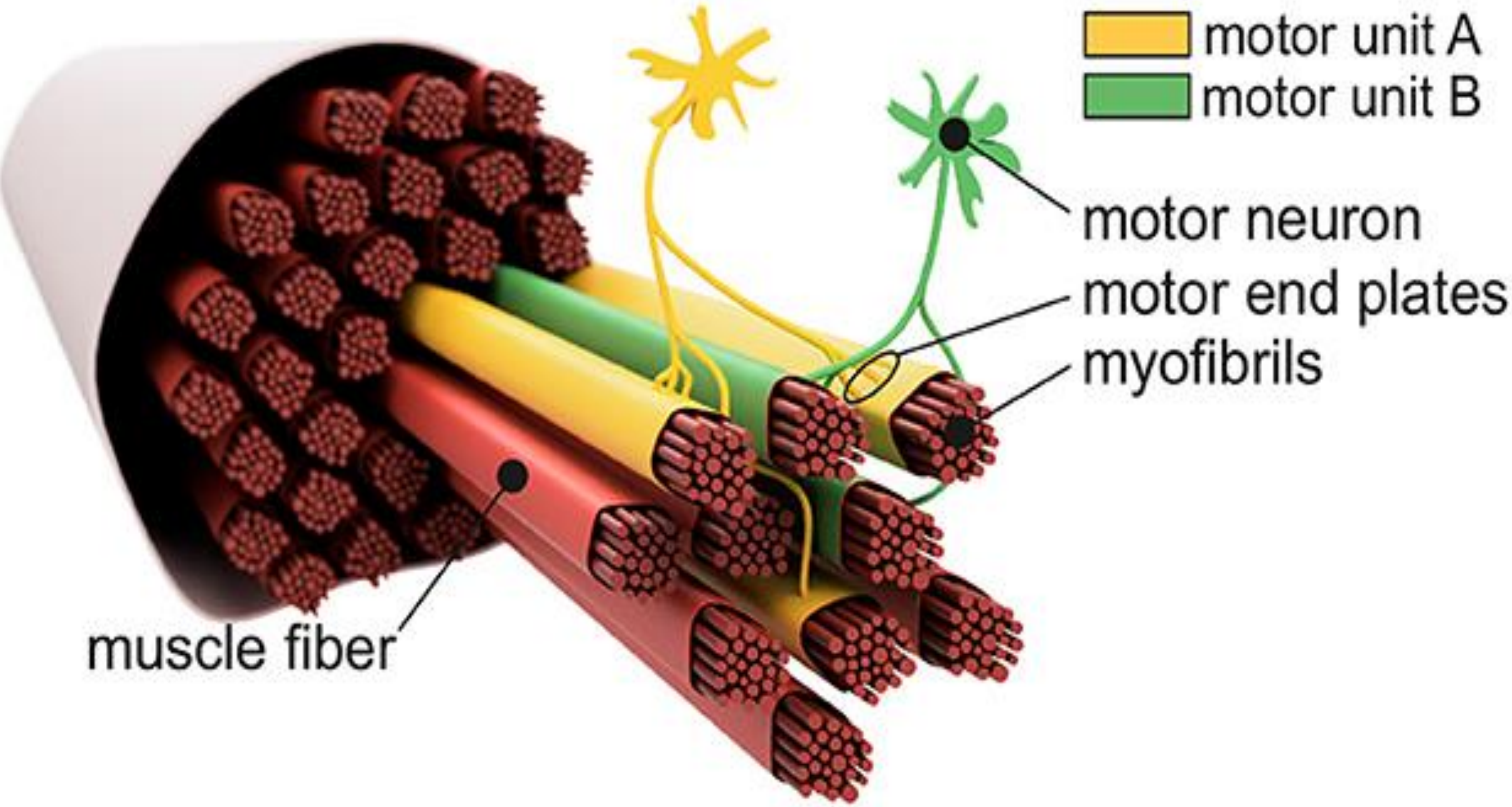
- The best known feature of skeletal muscle is its ability to contract and cause movement of Skeletal
- Muscles act not only to produce movement but also to stop movement, such as resisting gravity to maintain posture.
- Muscles also prevent excess movement of the bones and joints, maintaining skeletal stability and preventing skeletal structure damage or deformation.
- Skeletal muscles also protect internal organs (particularly abdominal and pelvic organs) by acting as an external barrier or shield to external trauma

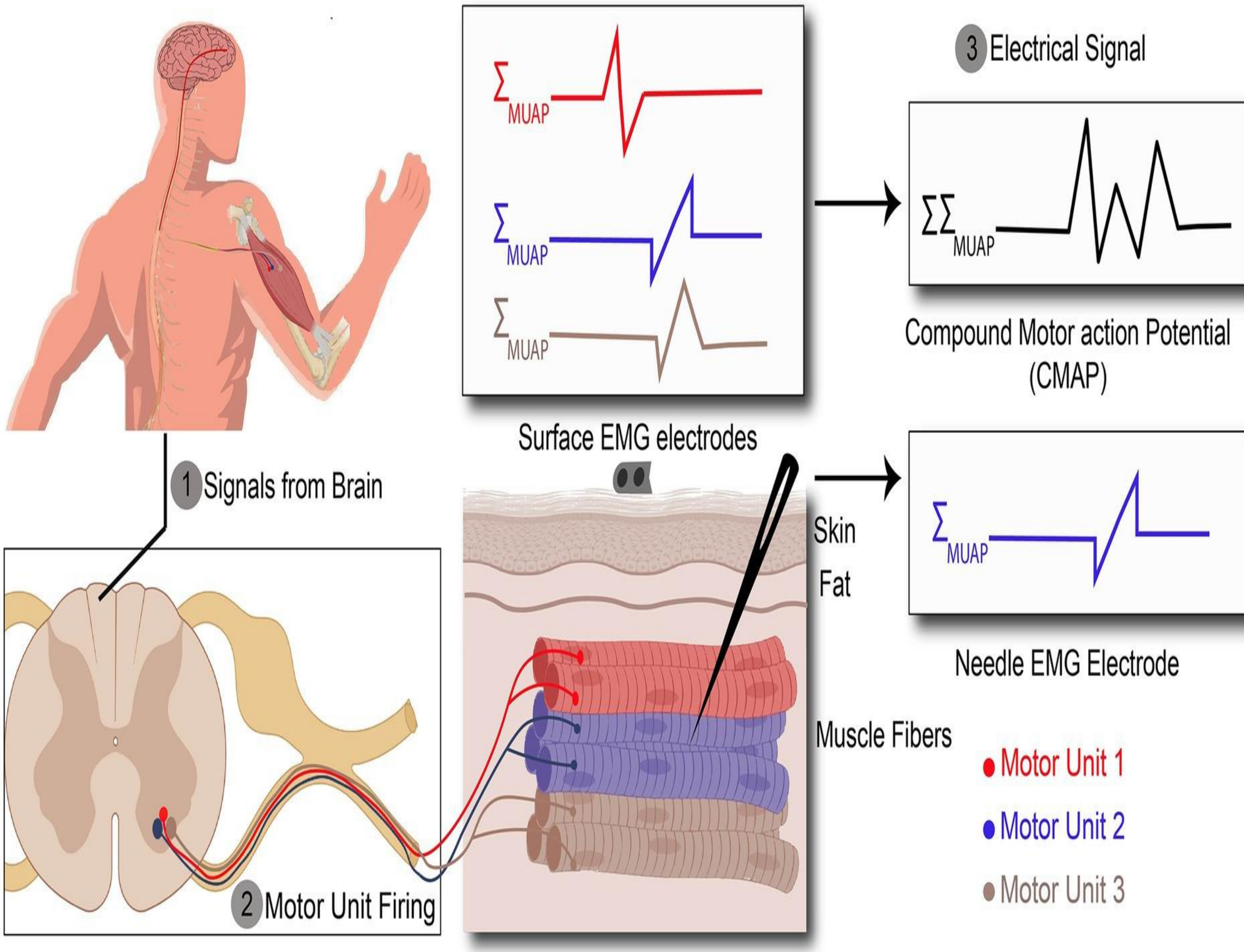
Skeletal Muscle Shapes



Physiological Basis of EMG

- **Muscle Contraction and Electrical Activity**: When a nerve impulse (action potential) reaches the neuromuscular junction, it triggers the release of acetylcholine, causing depolarization of the muscle fiber membrane. This generates an electrical signal, called the muscle action potential (MAP), which spreads along the muscle fiber, causing contraction. EMG measures this electrical activity.
- **Motor Unit Action Potential (MUAP)**: A motor unit consists of a motor neuron and the muscle fibers it innervates. During muscle contraction, the firing of the motor neuron results in a synchronized contraction of the muscle fibers in that motor unit. EMG captures the summated electrical activity of multiple motor units, which reflects the level of muscle activation.


motor unit A
motor unit B
motor neuron
motor end plates
myofibrils
muscle fiber



3 Electrical Signal
ΣMUAP
ΣMUAP
ΣMUAP
ΣΣMUAP
Compound Motor action Potential (CMAP)
Surface EMG electrodes
1 Signals from Brain
Skin
Fat
ΣMUAP
Needle EMG Electrode
Muscle Fibers
Motor Unit 1
Motor Unit 2
Motor Unit 3
2 Motor Unit Firing

How EMG Works:

When muscles contract, they generate electrical signals, which can be detected by EMG sensors placed on or inserted into the muscle. These sensors capture the electrical activity (muscle action potentials), which can then be amplified and analyzed to assess muscle function or diagnose neuromuscular disorders.

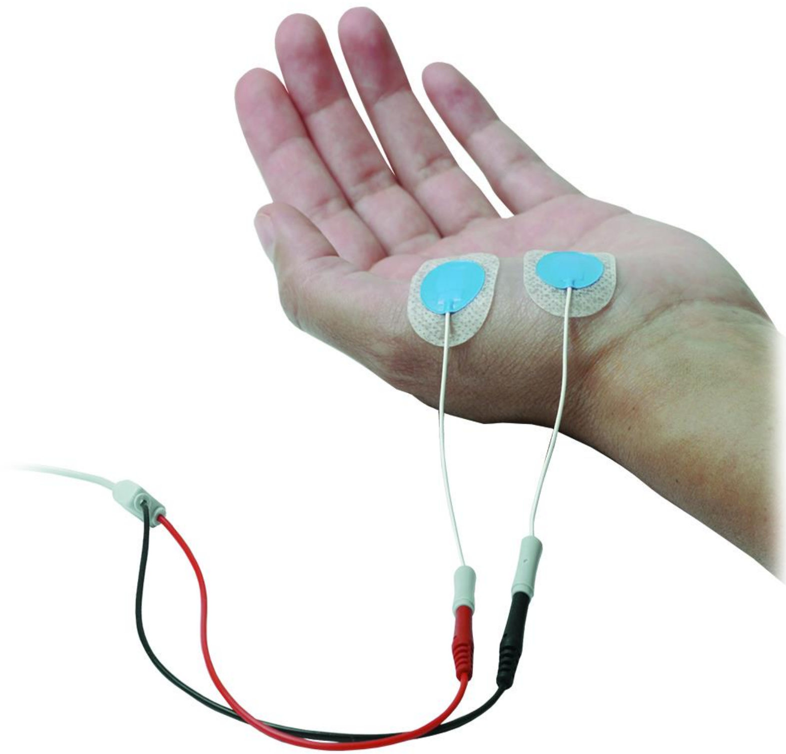
Types of EMG Sensors

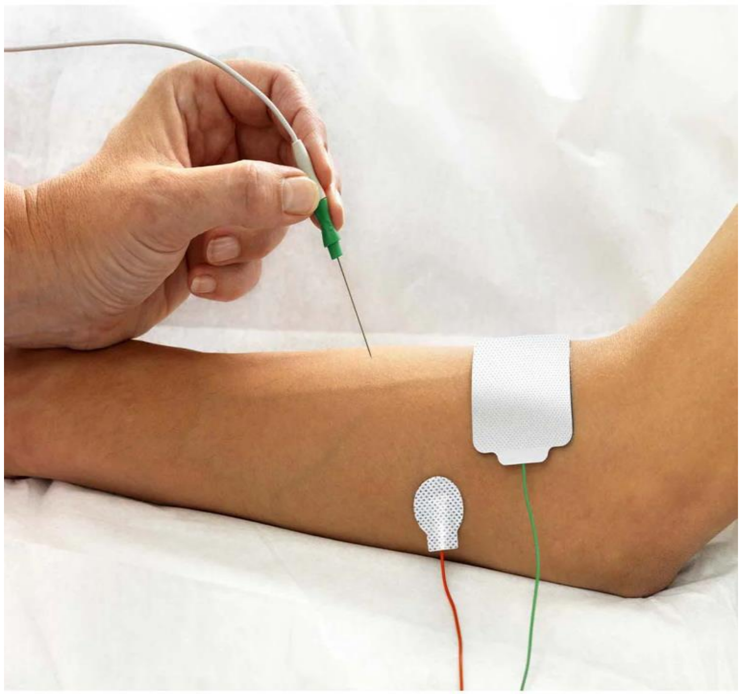
a. Surface EMG (sEMG) Sensors

- **Non-invasive**: These sensors are placed on the skin's surface to detect electrical activity from the muscles below.
- **Electrode Composition**: Typically composed of silver/silver chloride (Ag/AgCl) to ensure high conductivity and minimal signal noise. These electrodes are either:
  - **Pre-gelled disposable electrodes**: Single-use, self-adhesive, with conductive gel to improve skin contact.
  - **Reusable electrodes**: Often made of conductive metal, these require conductive gel or paste to enhance signal quality.
- **Shape and Design**: Surface electrodes can be circular or rectangular and come in various sizes depending on the muscles being measured.
- **Placement**: Electrode placement is critical for accurate signal acquisition. Electrodes are typically positioned over the muscle belly, parallel to muscle fibers to maximize signal strength and minimize noise.

b. Intramuscular EMG Sensors (Needle/Wire Electrodes)

- **Invasive**: Involves inserting a needle electrode or fine wire directly into the muscle tissue.
- **Needle Electrodes**:
  - Thin, insulated wires are threaded through a hollow needle, which is inserted into the muscle.
  - These electrodes are used to measure the electrical activity of deep muscles or to obtain more precise readings of specific muscle fibers.
  - Common in clinical diagnostics, particularly in detecting neuromuscular disorders.
- **Wire Electrodes**: Fine wires remain inside the muscle after the needle is withdrawn, allowing for longer-term monitoring during movement tasks.





Sensor Components

•Electrodes:

- **Surface Electrodes**: Usually adhesive, pre-gelled electrodes that stick to the skin.
- **Needle Electrodes**: Inserted directly into the muscle for more specific recordings.
- **Fine-Wire Electrodes**: Used in intramuscular EMG for continuous monitoring inside the muscle.

- **Amplifiers:** EMG signals are weak, typically in the range of microvolts (μV), so amplification is essential. Amplifiers boost the signal for further processing and analysis.
- **Filters:** EMG signals can contain noise (such as electrical interference from other sources), so filters (high-pass, low-pass, and notch filters) are used to eliminate unwanted frequencies.
- **Analog-to-Digital Converter (ADC):** Converts the amplified and filtered analog signal into a digital signal that can be processed by a computer.
- **Signal Processing Software:** The digital EMG signal is further processed to extract meaningful parameters such as muscle activation timing, signal amplitude, and frequency content.

Applications of EMG:

- **Medical diagnostics**: EMG is used to detect neuromuscular disorders like ALS, carpal tunnel syndrome, or myopathies.

- **Rehabilitation**: EMG biofeedback helps in physical therapy and rehabilitation to monitor and improve muscle function.

- **Ergonomics and Biomechanics**: Used to study muscle activity during movement to optimize performance or prevent injury.

- **Prosthetics Control**: EMG sensors are also used in controlling prosthetic limbs based on muscle activity.