The Muscular System

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Learning Outcomes

1. List the functions of muscle.

2. List the three types of muscle tissue and describe the locations and characteristics of each.

3. Describe how visceral (smooth) muscle produces peristalsis.

4. Explain how muscle tissue generates energy.
Learning Outcomes (cont.)

5. Describe the structure of a skeletal muscle.

6. Define the terms *origin* and *insertion*.

7. List and define the various types of body movements produced by skeletal muscles.

8. List and identify the major skeletal muscles of the body, and giving the action of each.
9. Explain the differences between strain and sprain injuries.

10. Describe the changes that occur to the muscular system as a person ages.

11. Describe the causes, signs and symptoms, and treatments of various diseases and disorders of the muscular system.
There are four characteristics associated with muscle tissue:

- **Excitability**: Tissue can receive & respond to stimulation
- **Contractility**: Tissue can shorten & thicken
- **Extensibility**: Tissue can lengthen
- **Elasticity**: After contracting or lengthening, tissue always wants to return to its resting state
Introduction

- Bones and joints do not produce movement
- The human body has approximately 640 individual muscles
- Muscles cause bones and supported structures to move by alternating between contraction and relaxation

You will focus on the differences among three muscle tissue types, the structure of skeletal muscles, muscle actions, and the names of skeletal muscles.
Muscle has the ability to contract, permitting muscles to perform various functions.

- Functions:
  - Movement
  - Stability
  - Control of body openings and passages
  - Heat production
Functions of Muscle: Movement

- **Skeletal muscles**
  - Attached to bones by tendons
  - Cross joints so when they contract, bones they attach to move

- **Smooth muscle**
  - Found on organ walls
  - Contractions produce movement of organ contents

- **Cardiac muscle**
  - Produces atrial and ventricular contractions
  - This pumps blood from the heart into the blood vessels
Functions of Muscle: Stability

- Hold bones tightly together
  - Stabilize joints

- Small muscles hold vertebrae together
  - Stabilize the spinal column
Functions of Muscle: Control of Body Openings and Passages

• Sphincters
  • Valve-like structures formed by muscles
  • Control movement of substances in and out of passages
  • Example:
    • A urethral sphincter prevents or allows urination
Functions of Muscle: Heat Production

- Heat is released with muscle contraction
  - Helps the body maintain a normal temperature
  - Moving your body can make you warmer if you are cold
Types of Muscle Tissue

- Muscle cells
  - *Myocytes* called *muscle fibers*
  - *Sarcolemma* – cell membrane
  - *Sarcoplasma* – cytoplasm of cell
  - *Myofibrils* – long structures in sarcoplasma
    - Arrangement of filaments in myofibrils produces *striations*
Microanatomy of a Muscle Fiber (Cell)

- Transverse (T) tubules
- Sarcoplasmic reticulum
- Terminal cisternae
- Sarcolemma
- Myoglobin
- Mitochondria
- Thick myofilament
- Thin myofilament
- Myofibril
- Nuclei
- Triad
## Types of Muscle Tissue (cont.)

<table>
<thead>
<tr>
<th>Muscle Group</th>
<th>Major Location</th>
<th>Major Function</th>
<th>Mode of Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skeletal Muscle</td>
<td>Attached to bones and skin of the face</td>
<td>Produces body movements and facial expressions</td>
<td>Voluntary</td>
</tr>
<tr>
<td>Smooth Muscle</td>
<td>Walls of hollow organs, blood vessels, and iris</td>
<td>Moves contents through organs; vasoconstriction</td>
<td>Involuntary</td>
</tr>
<tr>
<td>Cardiac Muscle</td>
<td>Wall of the heart</td>
<td>Pumps blood through heart</td>
<td>Involuntary</td>
</tr>
</tbody>
</table>
Types of Muscle Tissue: *Skeletal Muscle*

- Muscle fibers respond to the neurotransmitter *acetylcholine*
  - Causes skeletal muscle to contract

- Following contraction, muscles release the enzyme *acetylcholinesterase*
  - Breaks down acetylcholine
  - Allows muscle to relax
Types of Muscle Tissue: Smooth Muscle

- **Multiunit smooth muscle**
  - In the iris of the eye and walls of blood vessels
  - Responds to neurotransmitters and hormones

- **Visceral smooth muscle**
  - In walls of hollow organs
  - Responds to neurotransmitters AND
  - Stimulate each other to contract so that muscle fibers contract and relax together in a rhythmic motion – *peristalsis*
Types of Muscle Tissue: 

**Smooth Muscle (cont.)**

- *Peristalsis* – rhythmic contraction that pushes substances through tubes of the body

- Neurotransmitters for smooth muscle contraction
  - Acetylcholine
  - *Norepinephrine*
  - Will cause or inhibit contractions, depending on smooth muscle type
Types of Muscle Tissue: Cardiac Muscle

- Intercalated discs
  - Connect groups of cardiac muscle
  - Allow the fibers in the groups to contract and relax together
    - Allows heart to work as a pump

- Self-exciting – does not need nerve stimulation to contract
  - Nerves speed up or slow down contraction
Type of Muscle Tissue: Cardiac Muscle (cont.)

- Neurotransmitters
  - Acetylcholine – slows heart rate
  - Norepinephrine – speeds up rate
Production of Energy for Muscle

- ATP (adenosine triphosphate)
  - A type of chemical energy
  - Needed for sustained or repeated muscle contractions

- Muscle cells must have three ways to store or make ATP
  - **Creatine phosphate**
    - Rapid production of energy
  - **Aerobic respiration**
    - Uses body’s store of glucose
  - **Lactic acid** production
    - Small amounts of ATP

ATP = energy

Biology
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Production of Energy: *Oxygen Debt*

- Develops when skeletal muscles are used strenuously for several minutes and cells are low in oxygen.

Pyruvic acid

Converts to

Lactic acid which builds up

To liver for conversion to glucose, requiring more energy and oxygen to make ATP

Muscle fatigue

Oxygen debt
Production of Energy: Muscle Fatigue

- Condition in which a muscle has lost its ability to contract
- Causes
  - Accumulation of lactic acid
  - Interruption of the blood supply to a muscle
  - A motor neuron loses its ability to release acetylcholine onto muscle fibers
Structure of Skeletal Muscles

- Skeletal muscles
  - The major components of the muscular system

- Composition
  - Connective tissue
  - Skeletal muscle tissue
  - Blood vessels
  - Nerves
### Structure: Connective Tissue Coverings

- **Fascia**
  - Covers entire skeletal muscles
  - Separates them from each other

- **Tendon**
  - A tough, cord-like structure made of fibrous connective tissue
  - Connects muscles to bones

- **Aponeurosis**
  - A tough, sheet-like structure made of fibrous connective tissue
  - Attaches muscles to other muscles
Structure: Connective Tissue Coverings (cont.)

- **Epimysium**
  - A thin covering that is just below the fascia of a muscle and surrounds the entire muscle

- **Perimysium**
  - Connective tissue that divides a muscle into sections called *fascicles*

- **Endomysium**
  - Covering of connective tissue that surrounds individual muscle cells
Anatomy of skeletal muscles

- **Muscle**
- **Fascicle**
- **Surrounded by perimysium**
- **Endomysium**
- **Surrounded by endomysium**
- **Skeletal muscle fiber (cell)**
- **Surrounded by epimysium**
- **Skeletal muscle**
- **Surrounded by epimysium**
- **Tendon**
- **Surrounded by perimysium**

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Attachments and Actions of Skeletal Muscles

- Actions depend largely on what the muscles are attached to
- Attachment sites
  - **Origin** – an attachment site for a less movable bone
  - **Insertion** – an attachment site for a more moveable bone
Attachments and Actions (cont.)

- Movement usually produced by a group of muscles
  - **Prime mover** – muscle responsible for most of the movement
  - **Synergists** – muscles that help the prime mover by stabilizing joints
  - **Antagonist (agonist)** – produces movement opposite to prime mover
    - Relaxes when prime mover contracts
Attachments and Actions:  
*Body Movements*

**Flexion** – bending a body part

**Extension** – straightening a body part

**Hyperextension** – extending a body part past the normal anatomical position

**Dorsiflexion** – pointing the toes up

**Plantar flexion** – pointing the toes down

**Abduction** – moving a body part away from the anatomical position

**Adduction** – moving a body part toward the anatomical position
Attachments and Actions:  
**Body Movements (cont.)**

*Circumduction* – moving a body part in a circle  
*Inversion* – turning the sole of the foot medially

*Pronation* – turning the palm of the hand down  
*Eversion* – turning the sole of the foot laterally

*Supination* – turning the palm of the hand up  
*Retraction* – moving a body part posteriorly

*Protraction* – moving a body part anteriorly
Attachments and Actions:

*Body Movements (cont.)*

**Elevation** – lifting a body part; for example, elevating the shoulders as in a shrugging expression

**Depression** – lowering a body part; for example, lowering the shoulders
Checkpoint!

The doctor has asked you to abduct the patient’s leg so he can see the patient’s wound. In order to position the patient correctly, what will you have to do?

**ANSWER:** Move the patient’s leg away from its position in the anatomical position.
Major Skeletal Muscles

- The muscle name indicates
  - Location
  - Size
  - Action
  - Shape
  OR
  - Number of attachments of the muscle

- As you study muscles, you will find it easier to remember them if you think about what the name describes.
# Naming of skeletal muscles

<table>
<thead>
<tr>
<th>TERMS INDICATING POSITION, DIRECTION, OR MUSCLE FIBER ORIENTATION</th>
<th>TERMS INDICATING SPECIFIC REGIONS OF THE BODY*</th>
<th>TERMS INDICATING STRUCTURAL CHARACTERISTICS OF THE MUSCLE</th>
<th>TERMS INDICATING ACTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior (front)</td>
<td>Abdominis (abdomen)</td>
<td>Origin</td>
<td>General</td>
</tr>
<tr>
<td>Externus (superficial)</td>
<td>Anconeus (elbow)</td>
<td>Biceps (two heads)</td>
<td>Abductor</td>
</tr>
<tr>
<td>Extrinsic (outside)</td>
<td>Auricularis (auricle of ear)</td>
<td>Triceps (three heads)</td>
<td>Adductor</td>
</tr>
<tr>
<td>Inferioris (inferior)</td>
<td>Brachialis (brachium)</td>
<td>Quadriceps (four heads)</td>
<td>Depressor</td>
</tr>
<tr>
<td>Internus (deep, internal)</td>
<td>Capitis (head)</td>
<td></td>
<td>Extensor</td>
</tr>
<tr>
<td>Intrinsic (inside)</td>
<td>Carpi (wrist)</td>
<td></td>
<td>Flexor</td>
</tr>
<tr>
<td>Lateralis (lateral)</td>
<td>Cervicis (neck)</td>
<td></td>
<td>Levator</td>
</tr>
<tr>
<td>Medialis/medius (medial, middle)</td>
<td>Cleido/clavius (clavicle)</td>
<td>Shape</td>
<td>Pronator</td>
</tr>
<tr>
<td>Obliquus (oblique)</td>
<td>Coccygeus (coccyx)</td>
<td>Deltoid (triangle)</td>
<td>Rotator</td>
</tr>
<tr>
<td>Posterior (back)</td>
<td>Costalis (ribs)</td>
<td>Orbicularis (circle)</td>
<td>Supinator</td>
</tr>
<tr>
<td>Profundus (deep)</td>
<td>Cutaneous (skin)</td>
<td>Pectinate (comblike)</td>
<td>Tensor</td>
</tr>
<tr>
<td>Rectus (straight, parallel)</td>
<td>Femoris (femur)</td>
<td>Piriformis (pear-shaped)</td>
<td></td>
</tr>
<tr>
<td>Superficialis (superficial)</td>
<td>Genio- (chin)</td>
<td>Platys- (flat)</td>
<td></td>
</tr>
<tr>
<td>Superioris (superior)</td>
<td>Glosso/glossal (tongue)</td>
<td>Pyramidal (pyramid)</td>
<td></td>
</tr>
<tr>
<td>Transversus (transverse)</td>
<td>Hallucis (great toe)</td>
<td>Rhomboid</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ilio- (ilium)</td>
<td>Serratus (serrated)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inguinal (groin)</td>
<td>Splenius (bandage)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lumborum (lumbar region)</td>
<td>Teres (long and round)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trapezius (trapezoid)</td>
<td></td>
</tr>
</tbody>
</table>

* Terms indicating specific regions of the body include: Abdominis, Anconeus, Auricularis, Brachialis, Capitis, Carpi, Cervicis, Cleido/clavius, Coccygeus, Costalis, Cutaneous, Femoris, Genio-, Glosso/glossal, Hallucis, Ilio-, Inguinal, Lumborum.
## Naming of skeletal muscles

### Table 7-3  Muscle Terminology

<table>
<thead>
<tr>
<th>TERMS INDICATING POSITION, DIRECTION, OR MUSCLE FIBER ORIENTATION</th>
<th>TERMS INDICATING SPECIFIC REGIONS OF THE BODY*</th>
<th>TERMS INDICATING STRUCTURAL CHARACTERISTICS OF THE MUSCLE</th>
<th>TERMS INDICATING ACTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nasalis (nose)</td>
<td></td>
<td>Other Striking Features</td>
<td></td>
</tr>
<tr>
<td>Nuchal (back of neck)</td>
<td></td>
<td>Alba (white)</td>
<td></td>
</tr>
<tr>
<td>Oculo- (eye)</td>
<td></td>
<td>Brevis (short)</td>
<td></td>
</tr>
<tr>
<td>Oris (mouth)</td>
<td></td>
<td>Gracilis (slender)</td>
<td></td>
</tr>
<tr>
<td>Palpebrae (eyelid)</td>
<td></td>
<td>Lata (wide)</td>
<td></td>
</tr>
<tr>
<td>Pollicis (thumb)</td>
<td></td>
<td>Latissimus (widest)</td>
<td></td>
</tr>
<tr>
<td>Popliteus (behind knee)</td>
<td></td>
<td>Longissimus (longest)</td>
<td></td>
</tr>
<tr>
<td>Psoas (loin)</td>
<td></td>
<td>Longus (long)</td>
<td></td>
</tr>
<tr>
<td>Radialis (radius)</td>
<td></td>
<td>Magnus (large)</td>
<td></td>
</tr>
<tr>
<td>Scapularis (scapula)</td>
<td></td>
<td>Major (larger)</td>
<td></td>
</tr>
<tr>
<td>Temporalis (temples)</td>
<td></td>
<td>Maximus (largest)</td>
<td></td>
</tr>
<tr>
<td>Thoracis (thoracic region)</td>
<td></td>
<td>Minimus (smallest)</td>
<td></td>
</tr>
<tr>
<td>Tibialis (tibia)</td>
<td></td>
<td>Minor (smaller)</td>
<td></td>
</tr>
<tr>
<td>Ulnaris (ulna)</td>
<td></td>
<td>-tendinosus (tendinous)</td>
<td></td>
</tr>
<tr>
<td>Uro- (urinary)</td>
<td></td>
<td>Vastus (great)</td>
<td></td>
</tr>
</tbody>
</table>

*For other regional terms, refer to Figure 1-6, p.17, which shows anatomical landmarks.
An Overview of the Major Skeletal Muscles

Figure 7-11(a)
An Overview of the Major Skeletal Muscles

Figure 7-11(b)

Sternocleidomastoid
Trapezius
Deltoid
Infraspinatus
Teres minor
Teres major
Latissimus dorsi
Brachioradialis
Extensor carpi radialis

Tensor fasciae latae
Semitendinosus
Biceps femoris
Gastrocnemius
Soleus

Calcaneal tendon
Calcaneus

Rhomboid major
Triceps brachii
Flexor carpi ulnaris
Extensor digitorum
Extensor carpi ulnaris
External oblique
Gluteus medius
Gluteus maximus
Adductor magnus
Semimembranosus
Gracilis
Sartorius
Major Skeletal Muscles: The Head

- **Sternocleidomastoid**
  - Pulls the head to one side
  - Pulls the head to the chest

- **Frontalis**
  - Raises the eyebrows

- **Splenius capitis**
  - Rotates the head
  - Allows it to bend to the side

- **Orbicularis oris**
  - Allows the lips to pucker
Major Skeletal Muscles: The Head (cont.)

- **Orbicularis oculi**
  - Allows the eyes to close
- **Zygomaticus**
  - Pulls the corners of the mouth up
- **Platysma**
  - Pulls the corners of the mouth down
- **Masseter and temporalis**
  - Close the jaw
Major Skeletal Muscles: Upper Arm

- **Pectoralis major**
  - Pulls the arm across the chest
  - Rotates and adducts the arms

- **Latissimus dorsi**
  - Extends and adducts the arm and rotates the arm inwardly
Major Skeletal Muscles: Upper Arm (cont.)

- **Deltoid**
  - Abducts and extends the arm at the shoulder

- **Subscapularis**
  - Rotates the arm medially

- **Infraspinatus**
  - Rotates the arm laterally
Major Skeletal Muscles: Forearm

- **Biceps brachii**
  - Flexes the arm at the elbow
  - Rotates the hand laterally

- **Brachialis**
  - Flexes the arm at the elbow

- **Brachioradialis**
  - Flexes the forearm at the elbow
Major Skeletal Muscles: Forearm (cont.)

- **Triceps brachii**
  - Extends the arm at the elbow

- **Supinator**
  - Rotates the forearm laterally (supination)

- **Pronator teres**
  - Rotates the forearm medially (pronation)
Major Skeletal Muscles: Wrist, Hand, and Fingers

- **Flexor carpi radialis** and **flexor carpi ulnaris**
  - Flex and abduct the wrist

- **Palmaris longus**
  - Flexes the wrist

- **Flexor digitorum profundus**
  - Flexes the distal joints of the fingers, but not the thumb
Major Skeletal Muscles:  
**Wrist, Hand, and Fingers (cont.)**

- **Extensor carpi radialis longus** and **brevis**
  - Extend the wrist and abduct the hand

- **Extensor carpi ulnaris**
  - Extends the wrist

- **Extensor digitorum**
  - Extends the fingers, but not the thumb
Major Skeletal Muscles: *Respiratory*

- **Diaphragm**
  - Separates the thoracic cavity from the abdominal cavity
  - Its contraction causes inspiration

- **External and internal intercostals**
  - Expand and lower the ribs during breathing
Major Skeletal Muscles: *Abdominal*

- **External** and **internal obliques**
  - Compress the abdominal wall

- **Transverse abdominis**
  - Also compresses the abdominal wall

- **Rectus abdominis**
  - Flexes the vertebral column
  - Compresses the abdominal wall
Abdominal Muscles

- Sternocleidomastoid
- Pectoralis minor
- Internal intercostal
- Serratus anterior
- Rectus abdominis
- Internal oblique
- Transversus abdominis
- Linea alba (band of connective tissue)
- External oblique
- Aponeurosis of external oblique
- Trapezius
- Deltoid
- Pectoralis major
Major Skeletal Muscles: *Pectoral Girdle*

- **Trapezius**
  - Raises the arms
  - Pulls the shoulders downward

- **Pectoralis minor**
  - Pulls the scapula downward
  - Raises the ribs
Major Skeletal Muscles: *Leg*

- **Psoas major** and **iliacus**
  - Flexes the thigh

- **Gluteus maximus**
  - Extends the thigh

- **Gluteus medius** and **minimus**
  - Abduct the thighs
  - Rotate them medially
Major Skeletal Muscles: Leg (cont.)

- **Adductor longus** and **magnus**
  - Adduct the thighs
  - Rotate them laterally

- **Biceps femoris, semitendinosus, and semimembranosus**
  - Known as the hamstring group
  - Flex the leg at the knee
  - Extend the leg at the thigh
Major Skeletal Muscles: Leg (cont.)

- **Rectus femoris, vastus lateralis, vastus medialis, and vastus intermedius**
  - Extend the leg at the knee

- **Sartorius**
  - Flexes the leg at the knee and thigh
  - Abducts the thigh, rotating the thigh laterally but rotating the lower leg medially
Major Skeletal Muscles: Ankle, Foot, and Toes

- **Tibialis anterior**
  - Inverts the foot and point the foot up (dorsiflexion)

- **Extensor digitorum longus**
  - Extends the toes and point the foot up

- **Gastrocnemius**
  - Flexes the foot and flexes the leg at the knee
Major Skeletal Muscles: Ankle, Foot, and Toes (cont.)

- **Soleus**
  - Flexes the foot

- **Flexor digitorum longus**
  - Flexes the foot and toes
Checkpoint!

Your patient complains of hurting his hamstring when running today. You would look at what part of the leg, and what muscles would be involved?

**ANSWER:** You would look at the back of his leg, and the muscles involved would be the biceps femoris, semitendinosus, and semimembranosus. These three muscles are known as the hamstring group.
Muscle Strains and Sprains

- Strains – injuries due to over-stretched muscles or tendons
- Sprains – more serious injuries that result in tears to tendons, ligaments, and/or cartilage of joints
- RICE is recommended treatment for either
  - Rest
  - Ice
  - Compression
  - Elevation
**Muscle Strains and Sprains (cont.)**

- **Prevention**
  - Warm up muscles
    - A few minutes before an intense activity raises muscle temperature and makes muscle more pliable
  - Stretching
    - Improves muscle performance and should always be done after the warm-up or after exercising
  - Cooling down or slowing down
    - Before completely stopping prevents pooling of blood in the legs and helps remove lactic acid from muscles
Aging and the Musculoskeletal System

• Contractions become slower and not as strong
  • Dexterity and gripping ability decrease
  • Mobility may decrease

• Assistive devices helpful

• Routine exercise
  • Swimming
  • Physical therapy
## Diseases and Disorders of the Muscular System

<table>
<thead>
<tr>
<th>Disease</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botulism</td>
<td>Affects the gastrointestinal tract and various muscle groups</td>
</tr>
<tr>
<td>Fibromyalgia</td>
<td>Fairly common condition that causes chronic pain primarily in joints, muscles, and tendons</td>
</tr>
<tr>
<td>Muscular Dystrophy</td>
<td>Inherited disorder characterized by muscle weakness and a loss of muscle tissue</td>
</tr>
<tr>
<td>Myasthenia gravis</td>
<td>Autoimmune condition in which patients experience muscle weakness</td>
</tr>
</tbody>
</table>
Botulism
Fibromyalgia
Muscular Dystrophy
Myasthenia gravis
<table>
<thead>
<tr>
<th>Disease</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhabdomyolysis</td>
<td>A condition in which the kidneys become damaged after serious muscle injuries</td>
</tr>
<tr>
<td>Tendonitis (lockjaw)</td>
<td>Painful inflammation of a tendon and the tendon-muscle attachment to a bone</td>
</tr>
<tr>
<td>Torticollis (wryneck)</td>
<td>Acquired or congenital; spasm or shortening of the sternocleidomastoid muscle; head bends to affected side and chin rotates to opposite side</td>
</tr>
<tr>
<td>Trichinosis</td>
<td>An infection caused by parasites (worms)</td>
</tr>
</tbody>
</table>
Rhabdomyolysis

Rhabdomyolysis

"Kidney is unable to remove waste products, which results in serious condition known as Ketoacidosis"
Tendonitis (lockjaw)
Tendonitis (lockjaw)
Trichinosis
Trichinosis
Muscular dystrophy is an inherited disorder characterized by muscle weakness and a loss of muscle tissue.

**ANSWER:** Muscular dystrophy is an inherited disorder characterized by muscle weakness and a loss of muscle tissue.
In Summary

- **Skeletal muscles**
  - Voluntary control
  - Produce movement in conjunction with skeletal system
  - Help stabilize joints
  - Participate in heat production

- **Smooth muscles**
  - Involuntary control
  - Control body openings and passages

- **Cardiac muscles**
  - Involuntary control
  - Responsible for pumping action of the heart
Everyone has a 'risk muscle.' You keep it in shape by trying new things. If you don't, it atrophies. Make a point of using it at least once a day.

~ Roger von Oech
References:

Lakô hâ salamât!
Maraming salamat!