The Nervous System

- **Outward Nerves:**
  - Motor nerves: From Brain to muscles

- **Inward Nerves:**
  - Sensory nerves: From skin, eyes, ears, etc. to Brain

- **Autonomic system:**
  - Controls blood circulation, heart, etc.
### Nerve cells
- A Nerve cell can be up to a meter long, but, 1/thousands of cm thick.
- Nerve impulses are electro-mechanical
- They transfer electric impulses as fast as 120 m/s

### Nerves & Muscles:
- Muscle fibers are connected to nerve fibers
- Each nerve fiber is responsible for innervating a number of muscle fibers
- **Number** of nerve fibers connected to muscle fibers is directly proportional to the **dexterity** needed by the muscle

### Muscles
- There are about **650** muscles in the human body
- 40% of total body weight
3 Types of Muscles Fibers

1. Skeletal Muscle Fibers
2. Smooth Muscles Fibers
3. Cardiac Muscle Fibers

Structure of the Muscles

- Tendons:
  - Tendons are made up of strands of collagen
- Bundle of fibers
- Muscle fibers
- Actin + Myosin

Muscle & Tendons

- Muscles are bundled together, then end at a tough, non-elastic tendon, attached to the bone.
Tendon

Ligaments
- These are strong, rope-like fibers
- They connect bone-to-bone to form a Joint
- They have VERY poor blood supply
- Functions:
  - To bind bones together
  - Limit the range of motion at a joint
  - Form a sealed joint capsule that contains lubricating fluid for the joints

Fibers
- Muscles are made of fibers that enable them to shorten and lengthen, producing movements.
  - \( L_{\text{Range}} = 5 \text{ mm} - 140 \text{ mm} \)
  - \( D = 0.1 \text{ mm} \)
Muscle Fibers
- MUSCLE = large number of muscle FIBERS
- Typically, 100,000 – 1,000,000 fibers

Muscle Contraction
- The ability of the muscle to shorten to \( \frac{1}{2} \) its normal resting length
- Myosin Rods: Stationary
- Actin Filaments: Slide along Myosin

Metabolism
- A process in which the body takes in food/drink and converts them from **Chemical Energy** to **Mechanical Energy + Heat**.
- The LIVER transfers the digested, absorbed food to Glucose, Glycogen, and Fat.
- Glucose, then Glycogen are readily used by the body.
- Fat is the last reserve of energy in the body.
Byproducts of Metabolism

- H₂O
- CO₂
- Heat

Blood Supply

Range:
- 4 – 100 ml/min/100 gm of muscle
Dynamic vs. Static Activity

More on Static vs. Dynamic work
- Higher Energy consumption
- Higher Heart rate
- Longer rest periods needed
- High potential for ergo-related problems

Static Jobs include:
- Name some of Static jobs
Anthropometry

Factors in Design Range & Percentiles
- Ethnic diversity
- Gender
- Age

Percentile can be calculated:
- 95 Percentile:
  - $5p = m - 1.65 \text{ SD}$
  - $95p = m + 1.65 \text{ SD}$
- 83.5 Percentile:
  - $16.5p = m - 1.00 \text{ SD}$
  - $83.5p = m + 1.00 \text{ SD}$
- 50 Percentile:
  - $50p = m +/– 0 \text{ SD}$
How to design for humans

1. Decide who you are designing for
2. Decide which body measurements are relevant
3. Decide whether you are designing for the ‘average’ or extremes
4. Think about other human factors

<table>
<thead>
<tr>
<th>Your design target</th>
<th>Users that your design should accommodate:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy reach</td>
<td>Smallest user: 5th percentile</td>
</tr>
<tr>
<td>Adequate clearance to avoid unwanted contact or trapping</td>
<td>Largest user: 95th percentile</td>
</tr>
<tr>
<td>A good match between the user and the product</td>
<td>Maximum range: 5th to 95th percentile</td>
</tr>
<tr>
<td>A comfortable and safe posture</td>
<td>Maximum range: 5th to 95th percentile</td>
</tr>
<tr>
<td>Easy operation</td>
<td>Smallest or weakest user: 5th percentile</td>
</tr>
<tr>
<td>To ensure that an item can't be reached, operated</td>
<td>Smallest user: 5th percentile</td>
</tr>
<tr>
<td></td>
<td>Largest user: 95th percentile</td>
</tr>
</tbody>
</table>

Risk Factors
Ergonomic Biomechanics

Risk Factors
1. Awkward and/or static postures
2. Forceful Muscle Exertion
3. Contact Stress
4. Repetition (Frequency)
5. Vibration and Temperature

Risk of injury depends upon:
- Duration of exposure (how long)
- Frequency of exposure (how often)
- Intensity of exposure (how much)
- Combinations of risk factors

Risk Factors
- Duration - usually need hours of exposure before risk factors become a concern
- Can be all at one time or cumulative over the day
WHAT IS AN MSD?

- A Disorder **Caused by** Risk Factors **To** Body parts

Factors that affect MSD’s

1. Age
2. Gender
3. Smoking
4. Physical Activity
5. Strength
6. Anthropometry

1. **Age**
   - Aging causes natural loss of bone mass and soft tissue strength
   - MSD’s increase as people enter their working years (25-65 years)
   - By 35, most people would have had their first episode of back pain
   - Highest rates:
     - Males: 20-24
     - Females: 30-34
2. Gender

- Male : Female ratio of 1 : 3 for CTS
- Females have smaller Carpal Canals than Males
- Females have more Type I muscle fibers in the Trapezius muscle than Males
- Females are more apt to seek medical attention than Males
- More Females are employed in hand-intensive jobs than Males
- Males complain of DeQuervain's disease than Females (Males use hand tools more than Females)

3. Smoking

- +ve relationship between smoking and MSD's
- Back pain caused by coughing from smoking
- Coughing increases the abdominal pressure and intradiscal pressure which puts strain on the spine
- Nicotine diminished blood flow to vulnerable tissues, hence, increases the chance for MSD injury, and reduces the chance for natural recovery
- Smoking diminish mineral content of bone causing easy micro fractures
- Smoking causes vasoconstrictions, hence, an increased chance of Reynaud's disease

4. Physical Activity

- Lack of exercise increases the chance to MSD
- High aerobic capacity may benefit a worker who is exposed to such physiological demand
- Injured fit workers recover faster than normal people, because MSD symptoms are often relieved by physical activities
5. **Strength**

- Weaker workers are at 3:1 risk of getting back problems
- Job matching based on strength is beneficial

6. **Anthropometry**

- Studies showed that CTS and Low Back problems are associated with Weight and Height
- Obesity accounted for 2-2.5 times the risk for CTS because of the increased fatty tissue and hydrostatic pressure within the Carpal Canal
- Tall workers are significantly more associated with back problems
- Short workers are significantly more associated with neck and shoulder pains

**Cumulative Trauma Disorders (CTD)**

- *When the musculoskeletal system is overloaded by a succession of small traumas (micro traumas) which, taken one by one, do not injure but, by their cumulative effects, can lead to over-exertions.*
- CTD’s result from highly repetitive motion jobs
Recognizing CTD's

- The main symptoms may include:
  - Pain
  - Soft tissue swelling
  - Restriction of Joint Movement

Ligament Injury (SPRAIN)

- **SPRAIN**: When a joint is twisted beyond its range of motion, some fibers of a supporting ligament may be:
  - Partially torn (due to repetitive motion),
  - Completely torn, or
  - Ripped loose from the bone (due to a violent impact).

Muscle Injury

1. Muscle fibers can be strained/irritated
2. Small group of fibers can be torn apart
3. An acute blow/crushing
Injury Types

I. Tendon Disorders
II. Nerve Disorders
III. Neurovascular Disorders

III.2. Vibration Syndrome (Raynaud’s Phenomenon)

- Damage to Nerves due to:
  - Prolonged use of vibrating tools,
  - Forceful prolonged gripping, and
  - Exposure to cold
- This will damage blood vessels of the hand leading to spasms.
- Vibration causes decrease blood flow with O2 deficiency
- to the skin, muscle, and nerves with eventual permanent damage.

White Finger
Hand/Arm Troubles
- Tingling and/or numbness
- Blanching or whitening attacks occur (lasts about 5-15 minutes), typically enhanced by cold temperature
- Leads to Raynaud’s Phenomenon or White Finger (cold white or bluish in color, numbness), takes 6 mo. to manifest itself
- Gangrene sets in
- Finger amputations

Raynaud’s Phenomenon Treatment:
NO EFFECTIVE TREATMENT

Office Ergonomics
Neutral Postures

![Diagram of neutral posture]

Figure 3. Proper user position and support.

Chairs – Desired Features

- Adjustable height
- Proper backrest to support back
- Seatpan of proper size and shape
- Armrests (if provided)
  - Low and short enough to allow users to get close to work surface
  - Horizontal and vertical adjustability
- 5-Point base for stability
- Swivel and other features as needed for task

Other Desirable Workplace Features

- Adjustable height
- Ample leg room
- Adequate work space surface
- Absence of sharp edges
- Proper viewing distances
- Design & layout promotes neutral postures

By: Dr. Magdy Aklados
**Typical Posture Problems**

- Bent wrist (up, down, in, out)
- Long reaches (keyboard, mouse, telephone)
- Twisting (between keyboard and monitor)
- Feet dangling/crammed into small space
- Holding phone while typing
- Bent neck due to improper screen height
- Poor keyboarding technique
- Inadequate lumbar support
- Long duration static posture / inadequate breaks

**Which Postures Can be Improved?**

Illustrations from Washington State Department of Labor

**Keyboard Ergonomics**

- Types
- Height adjustment
- Alignment
- Wrist / Palm rests
- Slope (angle)
- Keying
Awkward Postures

Traditional Keyboards and Posture Issues

Other Keyboard Posture Issues
Ergonomic Biomechanics

Negative Slope

Conventional Keyboard

Keyboard with Negative Slope

Alternative Keyboard Designs

Alternative Mouse Designs
Evaluate the following office workstations from an ergonomic perspective

- What positive aspects do you see?
- What are the ergonomic risk factors?
- What improvements do you suggest?
General Steps
1. Adjust chair so person’s feet are comfortable on floor (or foot rest)
2. Check chair for proper fit
3. Adjust keyboard height for neutral posture of elbows, wrists, hands
4. Adjust monitor height so eyes are in direct line with upper screen
5. Adjust monitor, document holder, other equipment to reduce twisting and promote neutral postures
6. Evaluate room and task lighting and potential glare conditions. Identify needed improvements
7. Identify other factors that could cause discomfort and identify improvement options
Ergonomic Biomechanics

Lean/Stand assist lifts

Sling-Type Full Lift

For limited space
Ergonomic Biomechanics

Lateral Sliding Aid

Lateral Transfer Device

Resident Bathing Solutions

By: Dr. Magdy Akladios
Ergonomic Biomechanics

Ergonomic Idea Bank

Google “Ergonomics Solutions Washington State”

Work-Related MSDs Can Be Prevented (Cost/Ergonomic Control)

- $100-$550: 14%
- $501-$1,000: 22%
- $1,000-$2,000: 15%
- $2,001-$5,000: 35%
- Over $5,000: 22%
- Less than $100: 2%

Source: Auburn Engineers, Auburn, AL

Ergo-Easer Software