Module 1: Fuel for Life

Describe the role of nutrition in health

- An **essential nutrient** is a nutrient that the body **cannot synthesize** on its own -- or not to an adequate amount -- and must be provided by the diet.
- These nutrients are necessary for the body to function, grow and develop properly.
- The six essential nutrients include
    - Carbohydrates
    - Protein
    - Fat
    - Vitamins
    - Minerals
    - Water

Define nutrition science – a multidisciplinary science

- **Nutrition science** seeks to integrate information about the **food** we eat and how it is **processed** in the body.
- Nutrition science can be split into 2 categories
    - Before swallowing: many factors determine what food is available to us
    - After swallowing: body's biochemical and physiological processes required to process individual nutrients, extract energy and contribute to growth and maintenance
- Nutrition science encompasses:
    - Food production
    - Diet composition
    - Appetite, food intake, food preferences
    - Nutrient digestion and absorption
    - Intermediary metabolism of nutrients
    - Biological actions of nutrients
    - Nutrient requirements in individuals and populations
    - Nutrient deficiencies and toxicities, effects on health
    - Chronic effects of diet constituents
    - Therapeutic and preventive effects of foods
- Our **nutritional patterns** have shaped our **genes**, and our genes can impact **metabolism** of different nutrients.
- Research is starting to poke holes in the hypothesis that calorie-hoarding genes are causing the obesity crisis.
- **Human nutrition** describes the processes whereby cells obtain and utilise necessary substances to maintain life
- Exploring the processes requires a multidisciplinary approach and ranges from a molecular to a societal level
- Sources of knowledge about nutrition
    - Humans
        - Natural experiments (famine and war)
        - Controlled experiments (clinical trials)
        - Hunter-gatherers
        - Epidemiology
        - Case studies, e.g. individuals with rare disease
        - Patients reliant on intra-venous feeding
    - Animals
        - Feeding domestic (farm) animals
        - Controlled experiments (mostly) in rodents

Understand "nutrition" as an organism-environment (diet) interaction

Factors influencing nutrition

- Constitutional:
    - Cell nucleus (DNA/RNA)
- Cells (cells need to communicate to the nervous system that certain nutrients need to be ingested)

    - Metabolism
    - Internal environment
    - Circulation
    - All organ systems
    - Central nervous system
- External environment:
    - Food security/insecurity
    - Household characteristics; care
    - Social and economic circumstances
    - Housing, sanitation, politics
    - Agriculture, health services

Describe the relationship between nutritional state and health consequences and outcomes

Nutritional Situation	Health consequences, outcomes
Optimum nutrition Food-secure individuals with adequate, balanced and prudent diets	Health, well-being, normal development, high quality of life
Undernutrition: hunger Food-insecure individuals living in poverty, ignorance, politically unstable environments, disrupted societies, war	• Decreased physical and mental development • Compromised immune systems • Increased infectious diseases • Constant circle of undernutrition, underdevelopment, poverty
Overnutrition Form of malnutrition. Overconsumption of food, especially macronutrients, plus: • Low physical activity • Smoking, stress, alcohol abuse Defined by degree of overweight or obesity in an individual.	Chronic noncommunicable diseases (NCDs): obesity, metabolic syndrome, CVD, type 2 diabetes, certain cancers. Often characterised by overnutrition of macronutrients and undernutrition of micronutrients
Malnutrition Nutrition transition: Individuals and communities previously food insecure → confronted with abundance palatable foods → some undernourished	Double burden of infectious diseases plus NCDs, often characterised by too many macronutrients and too few micronutrients

- Carbohydrates provide energy; however, they are twice as heavy as fat thus it's easier to convert and carry it around as fat

Body composition

- Fat approx. 17%
- Protein approx. 17%
- Water approx. 60-70%

Biological and health significance of food depends on:

- Chemical composition of components
- Physical form
- Amount consumed

Food intake and dietary patterns are influenced by:

- The industrialisation of food production and distribution
- Availability of food
- Culture, cuisine and traditions
- Geographical location and environment
- Media images about female (and male) bodies
- Family lifestyle and routines around eating

- Individual preferences, food and nutrition knowledge, health beliefs
- Availability of food

A healthy diet:

- Satisfies energy requirements (macronutrients)
- Provides adequate amounts of micronutrients
- Reduces risk of disease
- Is safe to consume

OBESITY

- A condition of abnormal or excessive fat accumulation in adipose tissue, to the extent that health may be impaired
- Can be measured using BMI
    - BMI (body mass index) can be an inaccurate measure of body fat content and does not take into account muscle mass, bone density, overall body composition

$$BMI = \frac{weight_{(kg)}}{(height_{(m)})^2}$$

Growth and longevity

- **Across species**, a greater adult body mass is associated with a longer life span than a smaller adult body mass
    - Doubling of species body mass increases lifespan by 16%
- **Within a species**, body weight is inversely associated with lifespan

Appreciate the global consequences of changes in quantity and quality of food supply

Factors leading to starvation

Human population • Population growth exceeding food availability • Uneven distribution of food	**Climate** • Droughts, floods, winds, sandstorms	**Politics** • Trade sanctions • International debt • Asian meltdown
Environment • Depletion of natural resources • Poor soils: overuse, erosion, desertification • Pollution • Global warming	**War** • Destruction of crops • Forced migration • Refugees	**Social structure** • Urbanisation • Lack of land ownership • Cash cropping

795 million people undernourished in 2016

Distinguish between macro- and micro-nutrients and know the classes and sub-classes

Two nutrient types:

- Macronutrients – energy supplying nutrients, required in large amounts in diet
    - Fat
    - Protein
    - Carbohydrate
- Micronutrients – required in trace amounts for the normal growth and development of living organisms
    - Vitamins (vital to health)
    - Trace elements, e.g. calcium, zinc, iron, copper, selenium

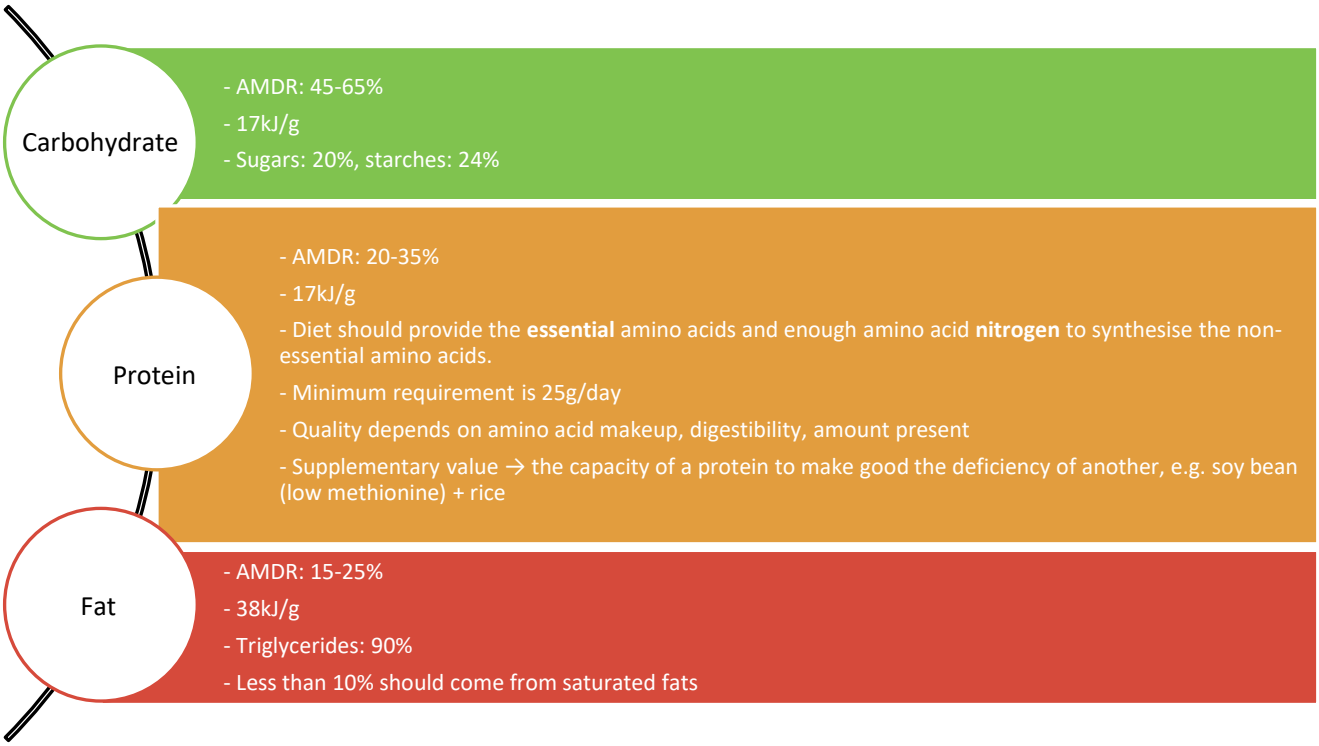
Classes of Macronutrients

Class	Subclass	Nutrient Examples
Carbohydrates	Monosaccharides	Glucose, fructose, galactose
	Disaccharides	Sucrose, maltose, lactose
	Polysaccharides	Starch and fibre
Proteins	Plant and animal source proteins	Amino acids: aliphatic, aromatic, sulfur-containing acidic, basic
Fats and oils (lipids)	**Saturated** fatty acids → each carbon is bound to two hydrogen atoms **Monounsaturated** fatty acids → missing one hydrogen bond **Polyunsaturated** fatty acids (n-3, n-6, n-9) → missing more than one hydrogen bond	Palmitic and stearic acid Oleic and elaidic fatty acids Linoleic, a-linolenic, arachidonic, eicosapentaenoic and docohexaenoic acid

Classes of Micronutrients

Class	Subclass	Nutrient Examples
Minerals	Minerals and electrolytes Trace elements	Calcium, sodium, phosphate, potassium, iron, zinc, selenium, copper, manganese, molybdenum, fluoride, chromium
Vitamins	Fat soluble	Retinol (A), calciferols (D), tocopherols (E), vitamin K
	Water soluble	Ascorbic acid (C), B1 (thiamine), B2 (riboflavin), B3 (niacin), B5 (pantothenic acid), B6 (pyridoxine), B7 (biotin), B9 (folic acid), and B12 (cobalamin)
Water	Water	Water

Contribution of macronutrients to total energy intake:

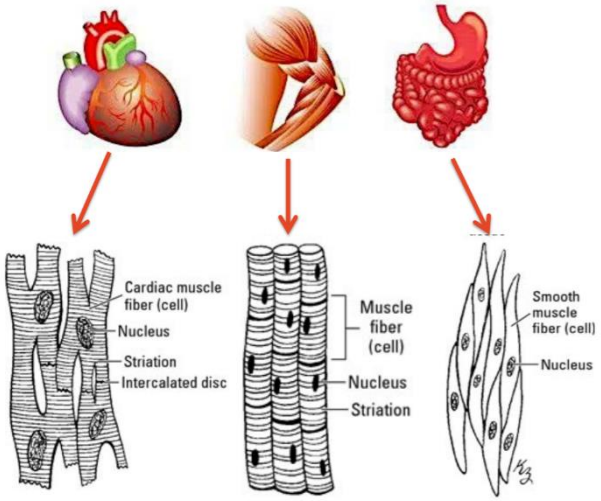


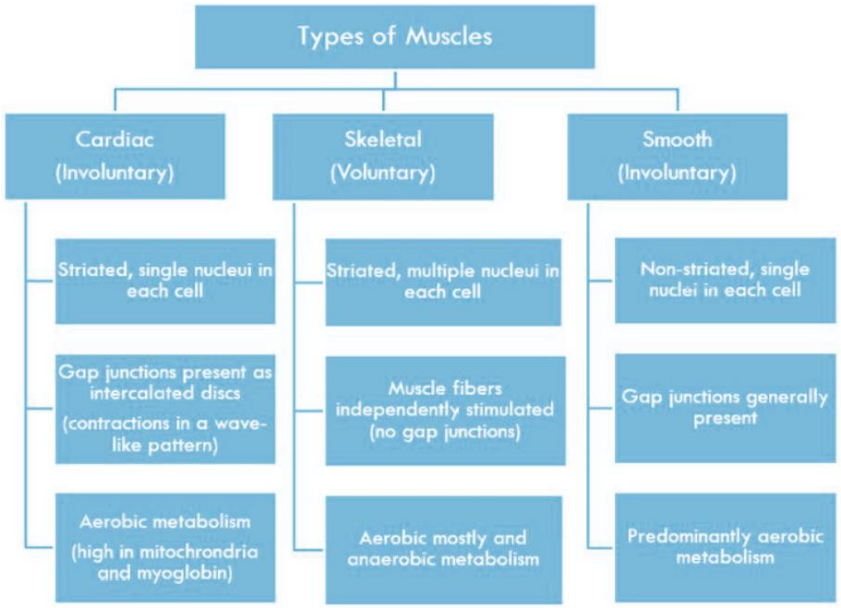
Module 2: Aerobic Health

Describe the microscopic structure of skeletal, cardiac and smooth muscle tissue

The Muscular System → 4 tissue types in the body:

Nervous tissue	Muscle tissue	Epithelial tissue	Connective tissue
• Brain • Spinal cord • Nerves	• Cardiac muscle • Smooth Muscle • Skeletal muscle	• Lining of GI tract organs and other hollow organs • Skin surface (epidermis)	• Fat and other soft padding tissue • Bone • Tendon





Describe the function and differences between the three types of muscle tissue

Importance of **cardiac** and **smooth muscles**:

- Ensure there is necessary **oxygen** and other vital **nutrients** for optimal bodily functions
- Aid **digestion**, move faeces, notify us of the need to release 'toxins' (both smooth and skeletal muscles)
- **Dilate and constrict** blood vessels (helps control blood pressure)
- **Thermoregulatory control** (body temperature)

Importance of **skeletal muscles**:

- Help us **move** – locomotion, exercise performance
- Maintain **posture** and body position
- **Support** soft tissue structures
- Guard and control body entrances and exits
- **Thermoregulation** and metabolic homeostasis
- **Store** nutrients (e.g. protein, glycogen)

Muscles cost energy

- **60-65%** of an adult's total energy consumption is used for maintaining everyday function (resting metabolic rate – cardiorespiratory function, thermoregulation, cell growth/repair, brain function and muscle function)
- Skeletal muscles uses **30%** of this (20% of total energy consumption)
- **~20-30%** of total energy consumption for everyday physical activities depending on your activity level

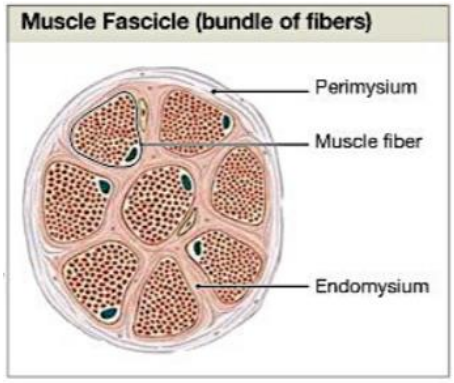
Describe the mechanism of contraction (sliding filament theory) and mechanisms by which they obtain energy (aerobic and anaerobic respiration)

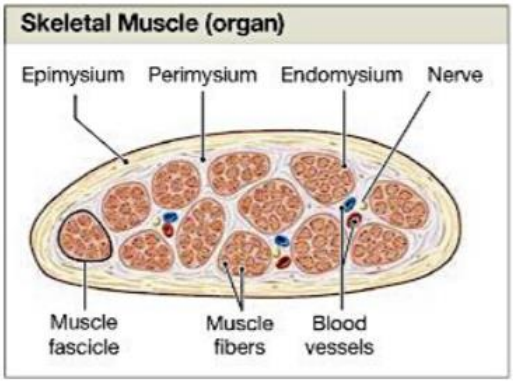
Muscles are supplied with energy through aerobic and anaerobic respiration:

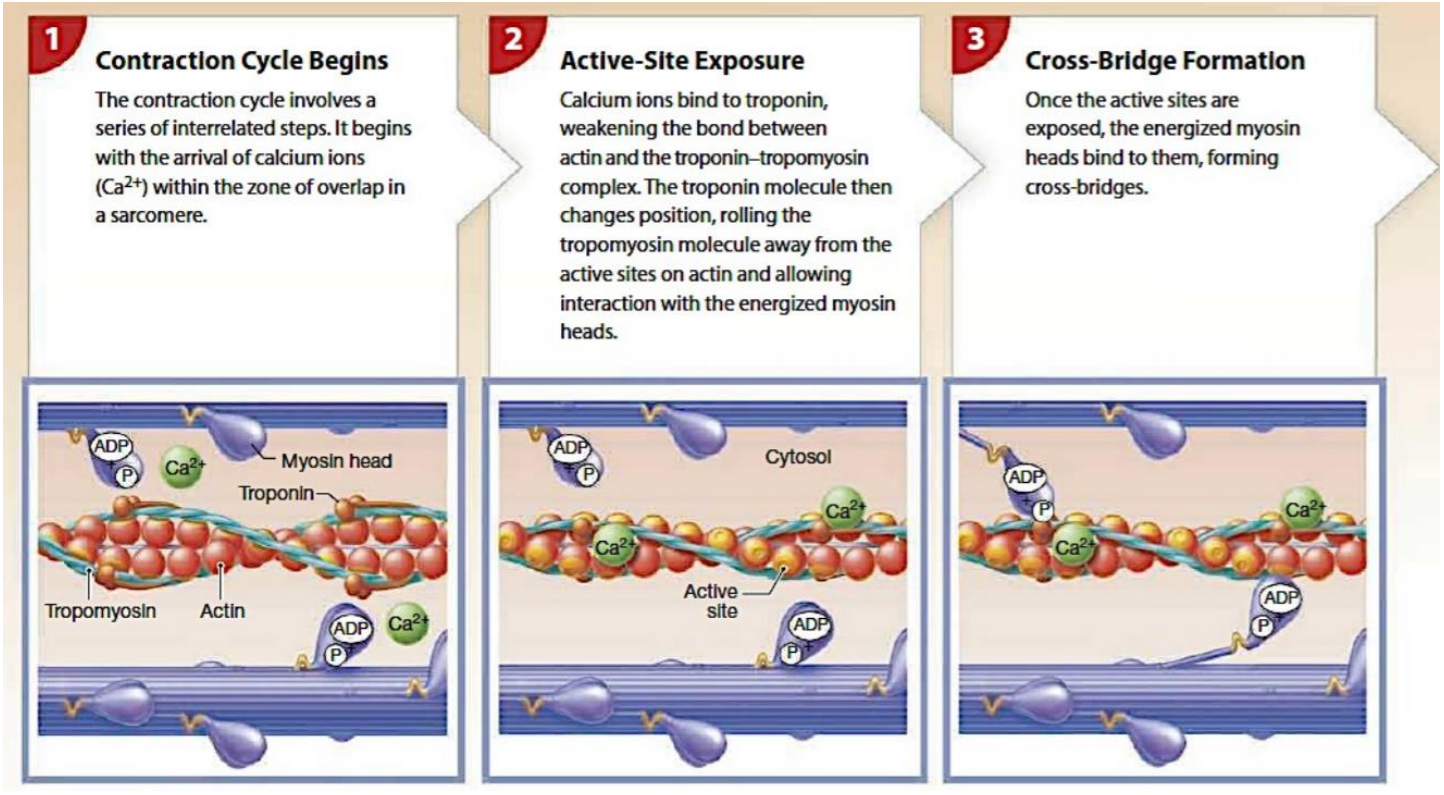
- **Aerobic Respiration** (using oxygen; not referring to breathing):
  - Glucose molecules are broken down to release energy **using oxygen** which our cells can use (an exothermic reaction)
    - Glucose + Oxygen → Carbon dioxide + Water + Energy
    - $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + Energy
  - Happens in 'mitochondria' in humans
- **Anaerobic Respiration** (Lactic Acid Fermentation):
  - Glucose molecules are broken down to release energy **without using oxygen** which our cells can use (an exothermic reaction)
    - Glucose → Lactic Acid + Energy
    - $C_6H_{12}O_6 \rightarrow 2C_3H_6O_3$ + Energy
  - Much less efficient process
  - Only used if oxygen is not readily available
  - Happens in cytoplasm (outside of the nucleus/organelles) of cells
- Note: Adenosine TriPhosphate (ATP) → short-term energy storage molecule, where the breakage of a molecular bond releases energy

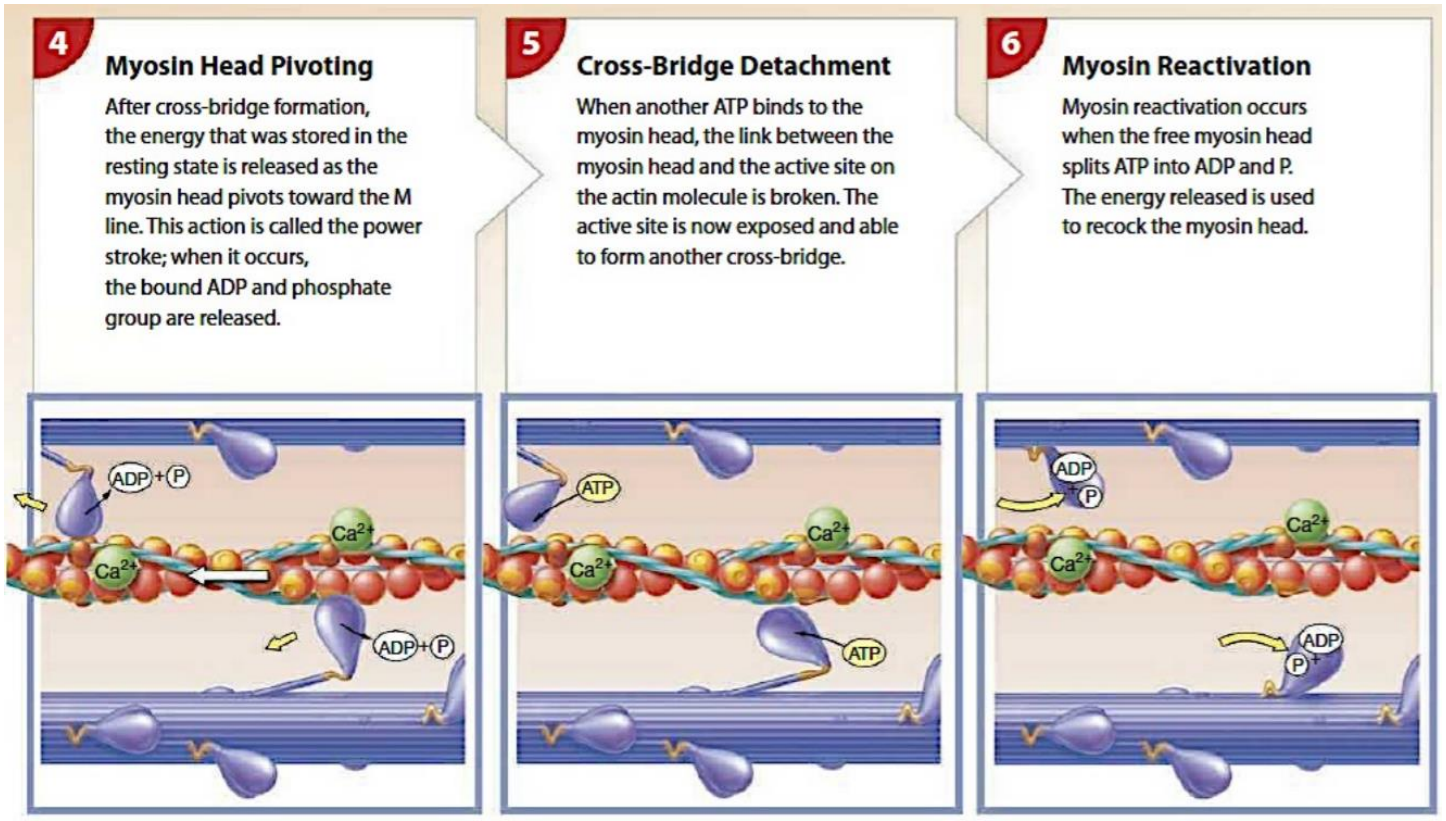
The Sliding Filament Theory → describes how muscles contract to produce force.

- Steps:
  1. Muscle activation
  2. Muscle contraction
  3. Recharging
  4. Relaxation



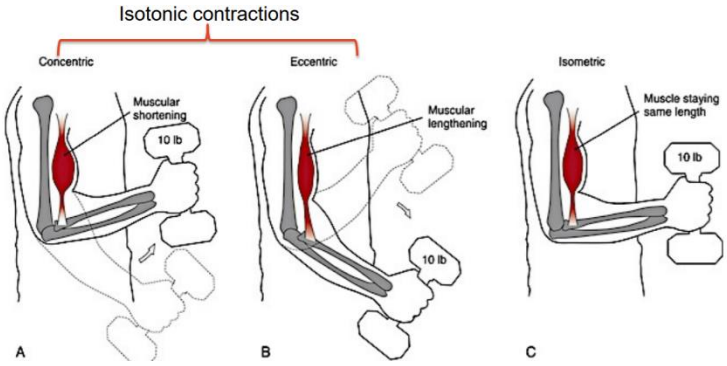






Types of muscle contractions:

- Concentric contraction → muscle shortens
- Eccentric contraction → muscle elongates, in response to a greater opposing force. Most energy efficient as we have connective tissue (passive structure you can't control that doesn't use energy) that stretches to slow you down
- Isometric contraction → muscle length stays same
- Increasing energy use (ATP): Eccentric → Isometric → Concentric
- Progression of maximal force (least to most): Concentric → Isometric → Eccentric



Relate the types of muscle fibres to muscle performance

Muscle fibre	Performance
Type 1 (slow twitch)	Long distance (marathons, triathlons) Breathing muscles – diaphragm, intercostals Fatigue resistant Low load, long duration
Type 2A (fast twitch oxidative)	400m/800m
Type 2B (fast twitch glycolytic)	Short sprints Glutes, gastrocnemius, calf muscles High load, short duration Fast, powerful contractions

Muscle fibre types

- Differ **across muscles**
- Change with **training** and lifestyle
- Differ across **ethnicity**

Property	Fast Fibers	Slow Fibers	Intermediate Fibers
Cross-sectional diameter	Large	Small	Intermediate
Time to peak tension	Rapid	Prolonged	Medium
Contraction speed	Fast	Slow	Fast
Fatigue resistance	Low	High	Intermediate
Color	White	Red	Pink
Myoglobin content	Low	High	Low
Capillary supply	Scarce	Dense	Intermediate
Mitochondria	Few	Many	Intermediate
Glycolytic enzyme concentration in sarcoplasm	High	Low	High
Substrates used for ATP generation during contraction (metabolism)	Carbohydrates (anaerobic)	Lipids, carbohydrates, amino acids (aerobic)	Primarily carbohydrates (anaerobic)
Alternative names	Type II-B, FF (fast fatigue), white, fast-twitch glycolytic	Type I, S (slow), red, SO (slow oxidative), slow-twitch oxidative	Type II-A, FR (fast resistant), fast-twitch oxidative

Explain the functional relationship between the muscular system and other body systems (in particular how basal metabolic rate, blood pressure and thermoregulation are influenced by the muscular system)

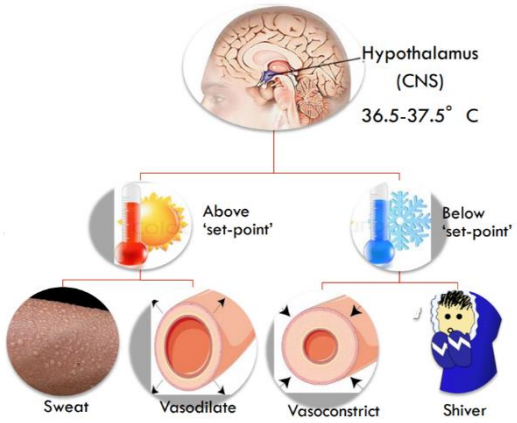
The Muscular System Working Together:

1. **Blood Pressure Control** – response to postural change:

- **Blood pools in the legs** when you stand from lying or sitting for long period.
    - Results in a decrease in venous return and decreased cardiac output → **hypotension**
- **Baroreceptors**, which detect stretch in blood vessels, are triggered to normalise this to maintain homeostasis.
- This **increases sympathetic activity** → raises heart rate, stroke volume and peripheral resistance to normalise BP
- Static postures (e.g. calf raises) would require the 'skeletal muscle pump' to prevent prolonged blood pooling

2. **Thermoregulation**:

- Controlled by three main physiological responses:
    - Sweating
    - Skin blood flow (smooth muscles)
    - Shivering (skeletal muscles)
- Thermoreceptors (PNS), free nerve endings, in the skin provides afferent input into the brain
- If hot → blood vessels **vasodilate**, skin **sweats**
- If cold → blood vessels **vasoconstrict**, skeletal muscles **shiver** to generate energy and heat



Describe, and differentiate between, the composition of the intracellular and extracellular fluids

- Water makes up approx. **60%** of total body weight
- The % of water varies between people
    - Babies and children > adult men > adult women > obese people
- The % of water varies within people
    - Lungs (83%) > brain (73%) > skin (64%) > bones (31%).
- Body water occupies 2 compartments:
    - Intracellular fluid (ICF – 66% of total body water)
    - Extracellular fluid (ECF – 33% of total body water)