Lecture Notes

Introduction to Fitness and Health

-Hippocrates: health = the right amount of nourishment and exercise
-Aristotle: cross section - better health from walking or being healthy makes you walk?7
-Lifestyle and health:
- Smokers aren't usually physically active nor will the stop smoking to become so
- More active people have better nutritional practices
- No relationship between PA and drinking alcohol
- Unknown relationship between PA and positive health/safety practices

-Stanley: no time for exercise = time to get sick
-Health continuum:
- "Unhealthy" = disease/death
    - Rehab – to treat diseases and make you healthy
- "Healthy" = absence of disease/symptoms (false just because you don't show symptoms does not mean you're healthy, with a negative lifestyle, you may soon)
    - Prevention – to enhance fitness
- "Fit" = optimum wellness

-Health care spending is going up
- $160.1 billion in 2007 (3.2% increase from the previous year)
- Because population is getting older and sicker
- We spend the fourth most on health care in the world (U.S. = 1st)
- Only 6% goes to public health (prevention)
    - The rest (94%) goes to helping people that are already sick (treatment)
    - Are trying to put more money into prevention but not enough (<0.2%)
        - Ex: disease prevention programs
            - More real PE teachers in elementary schools,
            - ParticipACTION (abandoned 1970s Schwarzenegger workout mentality for something everyone could do)

-With more awareness, people are getting more active… just not by enough
- About 42% in 2000

Health Care Systems

-World Health Organizations definition of health: a state of complete physical, mental, and social well-being, not merely the absence of disease/infirmity (is a human right)
-Health is determined by (which most Canadians do not have healthy access to):
- Behaviour (exercise, diet)
- Genetics
- Community/society
- Environment

-Lalonde framework (1974): determinants of health = human biology, health care organizations, environment, lifestyle
-Today's determinants of health:
- Quality of life
- Healthy environments
- Strong public health capacity

    - All three are dependent on:
        - A flourishing environment – green space, fruit/veggie availability, determines how much you drive
        - A vibrant and just society – are educated, take care of the less fortunate
        - Prosperous economy – can eat better, exercise, have a good health care plan, be educated

-Canada's health care system – "medicare" = publically funded

- Universal coverage for medically necessary health care services provided on the basis of need rather than the ability to pay
    - Good for severe health needs, bad for the "grey" areas of illness

-OHIP – provincially funded health coverage for ALL citizens

- Must be a Canadian citizen (born to Canadian parents), permanent resident, or in a special group for new comers that allows you to have one
- Have to be in Ontario for at least 153 days of the year (your primary place of res.)
- Immigrants must have been in Canada for at least 153 days
- Also covers home care, wheel trans, counselling community mental health services, portion of long-term health facilities, most of the drug costs for seniors/welfare people/people who face high drug cost

-US Medicare: rich people pay, lower income people/the elderly get financial help

-National Health Service medical model (UK and Canada):

- Primary care – medical clinics, etc., run by general practitioners (GPs), smallest domain (up to 50 000)
- Secondary care – specialty care (ex: paediatrics, neurology, general surgery), at hospital-based clinics, patients referred here by GPs, middle domain (up to 500 000)
- Tertiary care – teaching hospitals with high levels of expertise (ex: Sick Kids), cardiologists, etc., largest domain (up to 5 million)

-Spending 10% gdp on health care is considered ideas

- We spend more here (about $4079/person/year) ranked 3rd in life expectancy
    - is ever increasing because more people are developing chronic diseases, aging population, more technology, doctors getting paid more
- US spends way more because their doctors get paid a lot(high insurance because always getting sued)

-Canada is getting richer but spending more on health care leaving less funds for health unrelated needs

-Canadians can be left waiting up to 300 days for common surgical procedures (too long)

-Current health care system focuses on treatment of diseases (expensive)

- Need to promote healthy living before people get sick through (prevention – better and cheaper)
    - Self-care, mutual aid (so everyone has access) and health environments

-Inactive people get sick more/cost more to our healthcare system than active people

- Why Americans spend so much on health care

-Canada has the 6th lowest amount of deaths caused by preventable diseases (ex: from smoking) – and improvement

- US got worse – 15th to 19th

-Obesity levels are increasing leading to an increase in a bunch of related and preventable diseases

-Main problems to Canadian health care system: aging population, avoidable diseases caused by poor health habits, financing long-term care services/new and expensive technologies and pharmaceuticals, shortage and unbalance distribution of health care professionals
-Americans doctors make a lot more than Canadians grossly but the net value is about the same because insurance is so high in the US
-Illness/wellness continuum:
- Traditional Medicine – premature death > disability > symptoms (where medical attention is sought > signs (to neutral point) – Health Promotion (from neutral point) – awareness/growth > education > high-level wellness

-Precede (planning process)-Proceed (implementation/evaluation of programs):
- Planning > Proceed: regulating/resourcing/organizing for health education/media advocacy > government policy (ex: age restriction on cigarettes; force people to be healthier) > Precede: influences your predisposition (genetics), reinforces proper lifestyle, enables healthier living environments

-People used to die of infectious diseases, now they die of chronic ones (expensive to care for)
- Factors like smoking, poor nutrition and lack of exercise contribute to this

-Women live longer than men, even in the womb they have a greater chance of being born, is estrogen protective or do men have worse lifestyle habits?
- Life expectancy gap is closing… because females are picking up male lifestyle tendencies?
- 2005 life expectancy: females 82.7, males 78
    - Life expectancy predicted to continue rising

-2/3 Canadians due from heart disease/cancer/diabetes/accidents
- Both are preventable in many cases through healthy lifestyle changes

-Social determinants of health:
- Diversity/social exclusion (rich healthier than the poor)
- Income inequity
- Job security/working conditions
- Housing/food security
- Education/care in early life (how a child is nurtured in their 1st two years is indicative of their future health)
- Taken action

-Future of health and wellness relies on prevention, protection, risk assessment (who is more likely to develop a chronic disease), biomedical sciences
-Complementary and Alternative Medicine (CAM) – used by 48% of adults
- A group of diverse medical and health care systems, practices and products that are not generally considered part of conventional medicine
    - Ex: natural products (dietary supplements that are nonvitamin/nonmineral like herbs and fish oils), body medicine (yoga, meditation), manipulative/ body based practices (acupuncture, massage)
- Some work (like the kimono dragon spit for diabetics with high blood sugar), some are fake - need to be proven by a clinical trial
    - Are not overseen by health Canada because they're not real "drugs" – take with care and notify medical professional before mixing with prescriptions

-Best medicine = evidence-based medicine (EBM) – ex: from Canadian Diabetes Assoc.
- Levels of evidence:

Grade	Criteria
A	Best evidence was at level 1 (1A: includes high quality randomized control study/adequate power to answer the investigator's question. 1B: same but no control group)
B	Best evidence was at level 2 (not quite as good as level1)
C	Best evidence was at level 3 (case report assessed in one condition)
D	Best evidence was at level 4 or consensus (other/no studies done – possibly limited for ethical reasons)

-Health psychology: social, behavioural, cognitive and emotional factors that influence
- Maintenance of health, development of illness/disease, course of illness/disease after diagnosis, response to illness/disease by patient and patient's family
- Wants to optimize a person's health physically, mentally, emotionally, socially while preventing disease and illness
    - Good mental health is proven to help physical health
        - Promotes optimism, happiness, self-worth/efficacy, love, intimacy
    - Social well-being: ability to function in social roles such as work, family and recreation

-Psychometric evaluation = Short Form (36) Health Survey
- Categories: mental health, emotional health, social functioning, vitality (enthusiasm for life)
    - Asses if you are limited by any of these aspects or lack of them

-Estimated contribution of different factors to health status:
- 40% behaviour, 30% other factors, 20%genetic, 10% medical care

-Health psychologists promote health and prevent illness at the social or individual level
- Clinical health psychologists work with individuals to treat illness, slow/prevent it from getting worse and reduce disability
- Health psychology = related to behavioural health (sociology/nutrition/exercise phys.) and behavioural medicine (physiology)

-Biopsychosocial model of disease:
- Biology – genetic variability, anatomy, physiology
- Behavioural risk factors – diet, exercise, smoking, safe sex, wearing seat belt
- Pathogens – germs, toxins
- Social – family, society, friends
- Psychological component – behaviour (adoption and maintenance), emotional, cognition (thoughts/beliefs/attitudes), personality (ex: type A associated with heart disease)

-Contributions of psychology to health:
- Techniques in changing behaviour for better health
- Tries to make people healthy before they get sick
- Develops testable ways of assessing health-related factors
- Scientific methods for studying behaviour

<u>Behaviour Modification</u>

-Most North Americans accept that exercise is beneficial to health even though 51% of Canadians = inactive

-70% of new/returning exercisers are at risk of early drop out

-Exercise/exercise dropout cycle:

- Contemplate exercise > realize need for exercise > consider fitness course > enroll in fitness course > participate in exercise > course ends > stop exercising > find excuses for not exercising > repeat

-Most of our behaviours are a result of our environment (people/places/media/culture)
- Usually a "toxic" environment, we don't realize we're being influenced

-Steps/day:
- Active adults – 10 000+
- Active oldies – 8000
- Inactive adults – 3500-5000
- Recommended for children – 11 000-13 000
    - Average in Canada – 8000

-Environmental influences on PA
- Technological advancements – ex: we drive everywhere/are scared to walk in certain areas
    - Should walk 8-10 Km/day
    - Some environments are condusive to PA
        - Ex: Scandinavia… walk/bike everywhere
- Watch too much TV, snack a lot, sit for long periods of time, kids commute to school

-Environment affects diabetes:
- More prevalent in lower income neighbourhoods: less walking, worse public transportation, less educated, cultural predisposition to diabetes (African, Chinese, South Asian)

-Obesity epidemic worsening
- Americans consume double what they need to (3900 Cal)
- More $ spent on food advertising then positive nutrition programs
- Food socialization (activities planned/based on food)
- Portion sizes = bigger
- Ignore hunger cues… over eat (ex: Thanksgiving)
- "Value marketing" – ex: free refills…. Entices us to over consume
- Increased variety and energy density (all year round strawberries)
- Difficult to make habit changes (what health psychologists help with)

-Barriers to change:
- Lack of core values, procrastination, preconditioned cultural beliefs, miss instant gratification, risk complacency ("it doesn't affect me), feeling overwhelmed, indifference/helplessness, rationalization (think you're doing enough), think you're invincible

-Self-efficacy: belief in one's own ability to perform a given task
- Determines how you think, feel, act… your resiliency in the face of adversity
- Influences stress/depression levels
- Low: become a follower. High: may break down when overwhelmed because you are unable to control everything
- Sources: mastery experiences, vicarious experiences (ex: role model/visualizing success)

-Motivation: from within, triggered by external forces

-Locus of control (impacts how you make decisions):
- Internal/self-agency/personal control/self-determination (control own destiny)

    - Males more than females, more people become internal with age, high-ranking people in organizations tend to be internal
    - Related to higher academic achievement; believe working hard will pay off
    - Disadvantages: psychologically unhealthy/unstable, become anxious/depressed if you don't have a realistic sense of your abilities because you never reach success
- External (destiny controlled by fate, god, luck, others)
    - Influenced by religious beliefs, not seeing the results of your hard work, impoverished environments that can't be controlled, certain medications
    - Can be easy-going/relaxed/, are often happier than internals in mid-life
    - More likely to be external if you have confidence/competence/motivation problems
- Continuum (alternating between internal and external)

-Process of wilfully changing behaviour:

- Stop negative behaviour > prevent relapse > develop positive behaviour > strengthen this behaviour (rewards) > maintain this behaviour (until it becomes 2nd nature)

-Behaviour Change Theories:

- Learning theories: most behaviour is learned and requires reinforcement/expected outcomes
    - Modify small behaviours to shape the new pattern behaviour
- Problem solving model: identify where the problem is and educate yourself on how to fix it
    - Many behaviours are the result of decisions > to change requires constant attention and modified decision making
- Social cognitive theory: change is influenced by environment, self-efficacy, characteristics of the behaviour (change these = change behaviour)
- Relapse prevention model (for long-term change): anticipate lack of motivation, social pressure, negative physiological/psychological states and develop plans to avoid these
- Transtheoretical model: gradual change involving 6 steps:
    - Pre-contemplation > contemplation > preparation > action > maintenance > relapse (begin again) OR stable improved life style

-Change plans need to be individualized for success; timing is important

- Process: raise consciousness about the problem > social liberation (find alternatives to the lifestyle of your current society > decide that you want to change > emotional arousal (like scare tactics on cigarette boxes)
- Precontemplation: have a positive outlook, analyze your behaviour (so you know what/how to change), have achievable goals,
- Contemplation: emotional arousal, self-re-evaluate,
- Preparation: be committed,
- Action: reward yourself, counter (replace) bad habits with healthy ones, monitor yourself, change your environment to avoid relapse, surround yourself with encouraging people,

-Setting proper goals makes it easier to succeed:

- SMART goals = specific, measurable, acceptable, realistic, time-specific
- Focussed goals:
    - Intrinsic – under your own control, self-motivated instead of...
    - Extrinsic – not under your control, done for other people

-Healthy behaviour is shaped by:

- Predisposing factors (knowledge, attitude, beliefs, values, perceptions), enabling factors (skills, resources, accessible facilities, physical/mental capabilities), reinforcing factors (rewards, praise, recognition, sense of achievement)

-Maslow pyramid: fundamental requirements to health:
- Physiological needs > safety/security > love/affection > self-esteem > self-actualization

-Stress affects mental and physical well-being
- Hans Selye discovered the effects of physical stress while working with rats
    - Adrenal glands enlarge causing the hyper production of cortisol and epinephrine (stress hormones)
    - Thymus gland shrivels (immune system down)
    - Heart developed loss of strength (promotes health disease)

-Stress is: the nonspecific response of the body to any demand made on it
- Negative stress = distress, positive stress = eustress (some is good)
- Causes cortisol and caticolin response

-Addison's disease (no stress hormones)
- Muscle weakness, fatigue, weight loss, decreased appetite, low blood pressure/sugar, nausea, diarrhea, irritability, depression

-Stress hormones = cortisol (from cortex), epinephrine and norepinephrine (from medulla)
- In adrenal gland by the kidney

-Selye's General Adaptation Syndrome:
- Stressor – threatening/exhilarating
- Alarm – release of stress hormones, body responds with changes that lower resistance
- Resistance – if stressor continues, the body mobilizes to withstand the stress and return to normal
- Exhaustion – if stressor is ongoing, body resources become depletes and we function at less than normal
- Return to homeostasis (body systems maintain a stable and consistent state) OR Illness and Death (the body's resources are not replenished and/or additional stressors occur causing the body to suffer breakdowns)

-Types of stressors:
- Neurogenic – in your mind (ex: nightmare)
- Metabolic – energy levels/blood sugar drops (ex: no food for prolonged periods, running a marathon)
- Physical – pain/blood loss (ex: exercise, surgery)

-The stress response:
- FIRST (immediately) Sympathetic Nervous System (SNS)
    - The Locus Coeruleus
        - Integrates our senses so we can initiate a stress response
        - "pacemaker of the brain"
        - Causes norepinephrine secretion
        - Increases arousal and vigilance, modulates the action of the ANS
            - Regulates blood flow/pressure, HR, respiration, shuts down the gastrointestinal (GI) and sexual systems until crisis is over
    - The Limbic System
        - Functions: sets emotional tone, stores emotional memories, modulates motivation, controls appetite/sleep cycles, modulates libido

        - Chronic stress (if system over activated) causes breakdowns in these regions
- SECOND (takes minutes to hours)
    - Hypothalamic Pituitary Adrenal (HPA) axis – starts in the hypothalamus (which controls the hormones), sends a message to the pituitary gland then the adrenal glands where cortisol (causes biological reactions related to stress) is released
        - HPA system also gives you energy to get up in the mornings

-Physiological responses to stress:

- Nervous system – autonomic nervous system (ANS) is in charge of natural reflexes (breathing, heart rate, etc.), consists of the:
    - SNS (is activated by stressors, releases CATS like epinephrine/ norepinephrine)
    - Parasympathetic NS (calms you down…ex: slows heart rate)
- Endocrine System (allows you to fight longer) – HPA system and associated hormones… ACTH, Cortisol, Catecholamines ("CATS")…keep blood sugar and energy levels up

-Effects of stress:

- Immediate responses – breathing quickens, digestive system slows, increased alertness, HR quickens, adrenal glands produce stress hormones, muscles tense
- Effects of prolonged stress – renal hypertension, brains ability to remember is damaged by stress hormones (neurons die), feel anxiety more easily, blood clotting (increases risk of heart attack/stroke), increase/decrease appetite affecting body weight
- Too much cortisol for too long – immune system becomes supressed making body susceptible to all types of infections, headaches, anxiety, sleep disruption, menstrual disorders, impotence, troubles ejaculating

<u>Is Stress Hazardous to your Health?</u>

-In mice:

- stress + poor diet = gain abdominal fat (obesity)
- Stress + good diet = ok
- No stress + poor diet = ok

-In humans – stress is a risk factor for weight gain but the effects are very small

-Cushing's Syndrome – Elevated Glucocorticoids:

- Caused by high amounts of cortisol because of a tumor on the adrenal or pituitary glands
    - Excess cortisol can be eliminated by medication
- Moon face, buffalo hump, thin wrinkled skin, stretch marks, female can't menstruate, hard to distinguish gender of the person

-Fight or Flight Today… are bodies are used to handling short-term stress but we now experience it long-term… our bodies don't know what to do

-HPA axis is not always activated

- If it was we would experience physical exhaustion, immune/growth suppression, obesity, memory loss, etc.
- Cortisol turns itself off – negative feedback loop
    - Hypothalamus produces CRH > makes Pituitary gland secrete ATCH > tells adrenal glands to produce cortisol
    - If you exercise, your brain will have more receptors for the cortisol to attach to, making it easier to stop the production of CRH and, as a result, itself
    - Stress increases cortisol levels

-There are warning signs for stress overload
- How you cope with stress depends on personality
- Relax: breathing exercises, progressive relaxation therapy, replace bad thoughts with good ones, exercise, manage your time well

-Substance use, misuse and abuse
- 3.1 million people (13%) in Canada have used an illegal substance
    - About 1% admit they're addicted

-Routes of drug administration:
- Injection:
    - Intravenous injection – most dangerous, has the most potent effect because there is no physical barrier (it goes right into the blood stream)
    - Intramuscular injection – slower and less dangerous that intravenous injection
    - Subcutaneous injection
- Oral dosage – not as bad as injecting because stomach acts as a barrier
- Inhalation

-Dosage and Toxicity: depends on individual – body size, tolerance (until liver becomes damaged), capacity of liver to detox

-Over the Counter Medications – addictive: nasal sprays, laxatives, eye drops, cough syrup, sleeping pills, pain killers (about "30% of the class may be addicted to one of these")

-Prescription meds: 20% of North Americans have used prescription drugs for nonmedical reasons
- Narcotic pain killers, sedatives/ tranquilizers as "downers", stimulants (common in younger people)
- Oxycontin, like oral cocaine, being taken more than 3 times as much in 10 years, overall drug use increasing in children as young as 12

<u>Short-term and Long-term Effects of Marijuana</u>

-Negative long-term effects:
- Brain and central nervous system - sensory skills, short-term memory, coordination, brain chemistry, concentration, attention to detail
- Cardiovascular system – increase HR/blood pressure, decreases blood flow to limbs
- Respiratory system – 50% more damaging to lungs than tobacco, throat damage
- Reproductive system - impair ovulation, cause fetal abnormalities, affects fertility in men and supresses sexual functioning

-Positive short-term therapeutic effects:
- Brain and CNS – euphoric, minimize pain
- Vision – reduces pressure in the eyes (for people with glaucoma)
- Digestive system – helps with nausea from chemo, restores appetite in people who have lost weight from cancer/AIDS
- Muscular system – helps calm spasms

-Effects of cocaine use:
- Psychological problems, don't want to sleep/eat/have sex, cause strokes/seizures/brain damage, irregular heartbeat, damages heart tissue/lungs/mucous membrane in nose, affects ability to reproduce/carry a child to term

-Drug treatment - 4 000 000 + Americans didn't even realize they needed treatment

-Adults who used illicit drugs are twice as likely to have serious mental illness (16.6% of pop.)

-Impact of alcohol in excess:
- Effects digestive/cardiovascular/immune stystem
- Impaired perceptions/smell/taste/sensation/sense of space/motor skills/sexual performance
- Negative impacts your life socially (family, work, financially, legally, etc.)
- Increased risk of harm and dying:
    - In 2002 – 3197 people died in car crashes, MAD estimates 1161 of these deaths involved impaired driving

-63% of students drink twice a month or less
-Alcohol abuse: continued alcohol use despite adverse consequences, don't fulfill major obligations, related legal problems, using alcohol in hazardous situations
-Alcoholism: inability to control dinking, preoccupies with booze, continued alcohol use despite adverse consequences, distorted thinking
-Effects of nicotine:
- Stimulates NS, triggers tranquilizing morphine-like amino acids (excitement to relaxation) within 8 seconds, blood stream absorbs it, HR increases, vessel constrict increasing blood pressure
    - Adrenal production is stimulated, urine formation is inhibited, less oxygen reaches the heart

-Effects of smoking on the lungs:
- Bronchitis: bronchi inflamed and fill with mucous
- Emphysema: bronchioles (smallest air passages in the lungs) become less elastic
- Capillaries: cannot bring oxygen to the alveoli well
- Alveolar sac: get destroyed… no gas exchange
- Chronic obtrusive pulmonary disease: mucous build up blocks trachea

-Dental age: 30 years ago used to be able to identify person's age by the mineralization/demineralization of their teeth
- Fluoride treatment makes it less useful for predicting age in older people

-Can tell skeletal age by:
- Size of growth plate:
    - Bone consists of: upper epiphysis > growth plate (damaged at a young age can affect later growth) > metaphysis > diaphysis > metaphysis > growth plate > lower epiphysis
    - Proliferating zone – rapid mitosis of cells; hypertrophic cell zone – cells become enlarged
- How ossified (developed) bones are:
    - Develop from mesoderm cell > cartilage > bone

-You have more cartilage when you are younger (bones have more give, don't crack as easily)
- Bones get bigger and more dense (solid) over time

-To determine if a child is growing at the proper weight consider age/height/weight tables
- Don't use BMI because it is inaccurate in children

-There is a disadvantage, physically, to children born in the 2nd half of the year
- Are not as mentally/physically developed, though excel academically
- Coaches focus on bigger players giving them a further advantage over the "younger" kids

-Neilson and Cozens Classification Chart gives kids a score based on age and size and divides them according to this score

- Most leagues are divided by age (don't do this)

-Signs of puberty:

- Girls: onset of menses – menarche:
  - First menstruation
  - From ages 8-16 (usually around 12)
    - This age is lowering due to birth control pills getting into our water, obesity
      - Become sexually active younger, do worse in school
- Sexual development:
  - Tanner Stages I-V
    - Pubic hair growth, genitals (males), breasts (females)
    - By comparing your growth to a picture you can determine your stage

-Skin age: wrinkles caused by loss of elasticity; the whiter you are the easier you'll wrinkle

- 30 - forehead wrinkles
- 40 - crow's feet, laugh lines
- 50 – permanent web of lines around eyes/mouth, cheek skin loosens and sags
- 60 – bags under eyes, liver spots (made of coagulated pigment)
- 70 – thin, dry, wrinkled, "too big", yellowish waxy colour, ears/ nose become longer, nose broadens from accumulated cartilage

-Hair diameter indicates age: thins over time, amount of hairs decrease over time

- More in males

-Pathophysiology of male pattern hair loss (MPHL)

- Androgen-dependent (if testosterone binds well to the receptors on your head, hair will fall out)
- Passed on from mother's side of the family
- White people experience this the worst
- Treatment: finasteride 1 mg or minoxidil topical solution
  - Only stops hair from thinning, cannot make hair come back
  - Must be used on a constant basis, if you stop your hair will fall out anyways

-Causes of hair loss:

- Autoimmune conditions (like lupus), burns, infectious diseases (like syphilis), thyroid diseases, nervous habits, radiation therapy, tinea capitis (scalp ringworm), tumor on ovary/adrenal glands

-Height decreases with age:

- By the age of 70 by about 2.3 inches (more if you have osteoporosis)
- Also taller in the morning then the afternoon because intervertebral disks fill with fluid when you wake up (about 0.5 of an inch)

-You can control your physiological age

- Estimated by a person's health and probable life expectancy in terms of function
- The age of an individual expressed in terms of the chronological age of a normal individual showing the same degree of anatomical and physiological development
- Genetics also play a role
  - Ex: Carl Johnston – 85 year old pole vault world record holder

-Functional declines with age:

- Brain weight decreases by 15% by the age of 80 (prevent this by exercising your brain)
- Basal metabolic rate decreases by 5% by age 60 and 20% by age 80

    - Control heat, why old people are always cold
- Cardiac output decreases by 20% by age 60 and 30-35% by age 80
- Lung functioning decreases by 20% by age 60 and 45% by age 80
    - Also dependent on lifestyle (ex: smoking, etc.)

Lifestyle choices affect how quickly you age

Personal Nutrition

-Essential nutrients: we don't make them, provide energy, help build and maintain body tissues and regulate body function

- Ex: water, macronutrients, some vitamins/minerals

-Water:

- Body is 60% water
- Can live 50 + days without food but only a few days without water (depends on E stores)
- Used in digestion and absorption, where most chemical reactions take place in
- Recommended 2 L (8 cups) per day

-Macronutrients:

- Protein (4 kcal/g)
    - Helps build new tissue, provides fuel for body
- Carbs (4 kcal/g)
    - Provides energy
    - Types:
        - Simple – break down into energy faster (sugars: glucose/fructose/sucrose)
            - Bad if you have diabetes, good for athletes
        - Complex – break down slower (starches, refined, whole grain)
- Lipids (9 kcal/g) – more energy dense then proteins or carbs
- Alcohol (7kcal/g)
- Most foods contains some of each macronutrient

-Average energy expenditure – kcal/day

- University males close to 3000; university females a little over 2000

-Glycemic index "GI" of food (how quickly sugar enters your blood)

- Higher it is, the more quickly you will be hungry again

-Fibre (can't digest it so it cleans your colon)

- Lowers GI, binds cholesterol, lowers cardiovascular risk, binds water (so you drink more), softens feces relieving constipation and preventing hemorrhoids

-Fats:

- Saturated:
    - Functions: provide energy, trigger production of LDL ("bad" cholesterol)
    - Sources: red meat, dairy, egg yolks, coconut/palm oils
    - All single bonded (ex: stearic acid) – the worst type
- Unsaturated:
    - Functions: provide energy, trigger more "good" cholesterol (HDL) production and less "bad" cholesterol
        - Helps to prevent plaque build-up, bring floating cholesterol to the liver to be remetabolized
    - Sources: fish, avocados, olive/canola/peanut/vegetable oils, soft margarine
    - Have at least one double bond

        - On 6th C = omega 6 essential fatty acids – linoleic acid
            - Plentiful in North American diet: corn, wheat,
        - On 3rd C = omega 3 essential fatty acids – alpha linoleic acid
            - Lacking in North American diet, we need more of this: fish, canola oil, flax, green veggies
            - The best type – liquid at room temperature

-Trans fatty acids = not essential, related to heart disease, solid at room temperature

-Vitamins:

- Types:
    - Fat soluble = vitamins A, D, E, K
        - Stored in fat, can only be absorbed in fat, easier to overdose on because they are stored
    - Water soluble = vitamins B6, B12, C (get peed out, need a consistent amount because they don't stay stored for long), thiamin, riboflavin, niacin, folate, pantothenic acid, biotin
- Functions: regulate growth, maintain tissue, manufacture blood cells/hormones, antioxidant
- Sources: grains, cereal, pasta, fruit, veggies, nuts, some meat/dairy

-Minerals:

- Inorganic (no carbon), can be toxic in high amounts, 17 essential ones, regulate body function/growth/maintenance, ones lacking in our diet include iron, calcium, zinc, magnesium,
- Major minerals (need more of): sodium, potassium (effect blood pressure), calcium, phosphorus (effect bones), chloride, magnesium
- Trace minerals (need less of): iron, zinc, selenium, molybdenum, iodine, copper, manganese, fluoride, chromium
- Dietary recommended intake: between adequate amount and tolerable upper limit (beyond this gets dangerous)
    - Size of window between the 2 varies (ex: large in vitamins B and C)

-Nutritional problems associated with vitamins:

	Deficiency	Excess
Vitamin A	Poor night vision, weak immune system, rough skin	Orange skin, blurred vision, nausea, hair loss, death - overdose would be through supplements
Vitamin C	Scurvy – poor healing, weak immune system	Jaundice, nauseam headache, itchy skin - overdose would be through supplements)
Vitamin D	Rickets – fragile bones, depression, fatigue	Kidney stones, joint pain, constipation or diarrhea, fatigue
Iron	Anemia - fatigue	Nausea, organ damage
Iodine	Goiter, hypothyroidism	Hyper/hypothyroidism
Calcium	Osteoporosis, irregular HR, hypertension (high blood pressure)	Nausea, muscle weakness, excessive drowsiness, kidney stones

-New food guide = MyPlate (2001)

- Enjoy your food but eat less

- Half plate = fruits and veggies, half grains = whole grains, fat free/low fat milk, lean meats, lower sodium foods, drink water instead of sugary drinks, limit salt/alcohol/ caffeine

-American food pyramid = top heavy
-Understanding nutritional labels:
- The nutrient info is based on a specified amount of food that needs to be compared to the amount you eat
- The % Daily Value gives a context to the amount of the nutrient in the specified amount of food, based on recommendations for healthy eating

-Food labels:
- Calorie free = less than 5 kcal/serving
- Low in Calories = 40 kcal or less/serving; 120 kcal or less/100g (if a prepackaged meal)
- Lower in Calories/light = at least 25% less energy than original product
- Fat free = less than 0.5 g of fat/serving
- Low in fat = 3g or less of fat/serving; 30% or less of the energy is from fat (if a prepackaged meal)
- Reduced fat = at least 25% less fat than original product
- 100% fat free = less than 0.5 g of fat/100g; no added fat
- Organic = organic content is greater than 95%

<u>Physical Activity Guideline</u>
-Canadians are more active than before: 40% are meeting the physically active guidelines
- The wealthier/more educated you are, the more like you are to be physically active
- Younger people and women are more active

-Physical inactivity is associated with increased disease risk:
- Almost 2x more likely to get cardiac heart disease
- 1.4x more likely to suffer from stroke/hypertension/colon cancer/type 2 diabetes
- Also more likely to get breast cancer, osteoporosis, etc.
    - Eventually leading to death
        - About 21 340 (10.3%) of deaths are due to inactivity

-Costs due to inactivity = $2.1 billion
- Would save $150 million/year if physical inactivity levels were reduced from 62% to 56%

-Five components of health related fitness (exercise increases all of these):
- Cardiorespiratory endurance, muscular strength, muscular endurance, flexibility, body composition

-Benefits of exercise (physical and mental):
- Improves mood/appearance, reduces psychological symptoms, increases cardiorespiratory capacity, reduces risk of heart disease, aids digestion, reduces body fat and limits weight gain, strengthens bone and improves flexibility, increases muscle strength and tone, improves circulation (important for diabetics) to name a few

-Fitness movement began in the 70s
- "No pain, no gain" mentality turned people off to PA
- Increased interest in running, body building, aerobics

-You do not have to work as often or intensely to see health benefits (see these first) as you do to see fitness benefits (see these later)

- The more you do, the more benefits you'll see

-Canada's Physical Activity Guide (rainbow):

- Spend time most to least:
    - Endurance activities: 4-7 days/week
    - Flexibility activities: 4-7 days/week
    - Strength activities: 2-4 days/week
    - Reduce sedentary time (has independent risk factors if you exercise but still sit too much, could be worse than not exercising but sitting less)

time needed depends on effort: light = 60 min, moderate = 30-60 min, vigorous = 20-30 min

- Different guides for seniors, adults, youth, kids, families, teachers
- "Everyone can do it"
    - Ex: taking the stairs, walking more, reduce inactivity
- In kids – 60 min of moderate and 30 min of vigorous activity/day + decrease inactive time by 90 mins

-Exercise/Physical Activity Guidelines:

Old	New
Healthy adults	Every adult
Continuous	Accumulate (in bouts of at least 10 minutes)
20 + minutes	30 – 60 minutes
3-5 times a week	Most, if not all, days of the week
Vigorous (increases VO2 max)	Moderate

<u>Behaviour Change</u>

-self-esteem increases with participation in PA and good dietary habits; decreases with alcohol, tobacco, and drug use

-Stages and processes of change:

- Stage 1: Precontemplation – not intending to make changes
    - Give good reasons for why change would be good/beneficial
- Stage 2: Contemplation – considering change (in next 6 months)
    - Replace uncertainty with encouragement, highlight specific benefits, build self-efficacy
- Stage 3: Preparation – making small changes or ready to change in the near future
    - Make a plan/set a target date (establishes a commitment), focus on the pros, get helpful resources
- Stage 4: Action – actively engaging in new behaviour
    - Support to prevent relapse, teach to deal with lapses, promote social support, reward yourself
- Stage 5: Maintenance – sticking with the behaviour change
    - Continue support, prepare for relapses, refine/add variety to program, reward yourself

-Factors affecting participation in PA:

- Health benefits:
    - Beliefs: shaped by ourselves, others, media
    - Attitudes: values attached to beliefs
    - Intentions: a plan to change, how you'll do it, committing to it
        - Be realistic, make SMART goals, reinforce yourself with rewards

- Enjoyment/pleasure:
    - Feel better: physically, mentally
    - Achievement/success: individual or competitive basis
    - Social involvement: more fun + you can support each other
- Body and self-image:
- Practical considerations: environment, facilities, equipment, time, money

-Principles of exercise prescription

- Why – purpose
    - Enhance physical fitness, decrease disease, ensure safety during PA
- What – regimen of PA designed
    - Reach SMART goals in a systematic and individualized manner
- How – FITT (goal dependent)
    - Frequency: how often
    - Intensity: how hard
    - Time: how long
    - Type
- To get fitness/physical health/mental health benefits

-FITT for cardiorespiratory fitness:

- F: 3-5 times/week
- I: lower intensity for longer durations OR higher intensity for shorter durations
- Time: 20-60mins of continuous or intermittent aerobic activity/day OR more than 30 mins at lower intensities
- Type: any activity that uses large muscle groups is rhythmic and aerobic and can be continuously maintained

-FITT for muscular fitness:

- F: 2-3 days/week for each major muscle group
- I: max/near max effort, 8-12 reps/set
- Time: 20 min/set, 50 min/3 sets
- Type: static (isometric) and dynamic (isokinetic)

-FITT for flexibility:

- F: 2-3 days/week for each of the major muscle groups
- I: to point of mild discomfort
- Time: static stretches held for 10-30 seconds, PNF 6 second contraction followed by a 10-30second stretch
- Type: static, dynamic or Proprioceptive Neuromuscular Facilitation (PNF)

-Should spend weekly:

- 1-5 hours on cardio fitness and body composition
- 1-3 hours on muscular strength and endurance
- 1-2 hours on flexibility
- 3-10 hours total
    - Less than 20% of adults perform 3 hours of exercise/week
    - A very small % spend an appropriates amount of time on all 5 components of physical fitness

-Interpretation of curves

- A – many of the benefits are attained at low to moderate levels of PA (what national PA recommendations are based on)

    - Ex: biggest drop in mortality possibility when your move from being sedentary to active
        - Hypertension, diabetes
- B – linear relationship between PA and weight loss
    - Smoking, BMI
- C – relationship between PA and aerobic fitness improvements: greatest benefits are obtained as the level and intensity of PA gets higher
    - Ex: breast cancer risks, total cholesterol

-If you exercise too hard you could get sick because your immune system is being repressed

-Most common measure of obesity = BMI (accurate in people above the age of 18)

- $\frac{\text{weight (kg)}}{\text{height (m squared)}}$
- Black/White/Spanish:
    - Underweight: < 18.5, increased risk of health problems
    - Normal: 18.5-24.9, least risk of health problems
    - Overweight: 25-29.9, increased risk of health problems
    - Obese: 30+
        - Class 1: 30-34.9, high risk of health problems
        - Class 2: 35-39.9, very high risk of health problems
- Indicators of normal weight, etc. are lower in Asians

-Techniques of assessing body fat:

- Most accurate = cadaver analysis: chemical analysis, dissection
    - Irreversible; used to compare to reversible methods (get fat predicting equations)
    - Take skinfold measurement, peel off layers: skin, sub-Q fat, muscle. Now have fat, muscle and skeletal masses
- Total body density (DEXA), computer assisted tomography (CAT scan), magnetic resonance imaging (MRI)
    - DEXA: X-ray checks body density, fat is easy to see through (so you do NOT want to be able to see through yourself), used to measure bone density in hospitals), minimal radiation exposure
    - CAT scan: x-rays of your body give cross-sectional images so you can see muscle, bone, and fat layers, high radiation levels so are not used for measuring body composition
    - MRI: 3D reconstruction of the body, uses magnets to change spins of electrons in cells, very expensive so not used for body composition findings
- Age, height, weight tables
- Densitometry – indirect comparison (density = weight in a given area, volume divided by weight)
    - Fat has a lower density then muscle (therefor if you're less dense then you have more fat and more dense means you have more muscle/bone)
        - Measured in water (hydrostatic weighing) or in bod pod (pumps air in and out, $200 000)
    - Formulas are made for white people; black people = more dense, Asian people = less dense
- Skinfold measurements
    - Skin calipers cost $20-$600 (plastic = not as good, doesn't measure evenly)

    - Different equations (based on cadavers) for males, females, people between the ages of 16-30 and older than 30 (because there is a difference in fat composition as you age)
    - Yuhasz equation measures 6 skinfolds: tricep, back, hip, abdomen, front thigh, chest (males)/rear thigh (females)
        - Multiply then add/subtract (depends on equation) to get %
        - Healthy = 9% or less (males), 13% or less (females)
    - Durnin equation measures 4 skin folds: back, hip, tricep, bicep (no lower body)
        - Refer to table for body fat %
        - Healthy = 19% or less (males), 20.5% or less (females)
    - These 2 equations yield different %, so you must be consistent in your choice of equations
        - Both will give the same recommended weight loss values
    - Other equations can measure up to 12 skinfolds
    - Skin-cadaver validation study findings:
        - Aging affects (increases) compressibility of sub-Q fat and changes skinfold measurements for the same thickness
        - In the waist area, a ratio of 50:50 for sub-Q fat to internal fat is reasonably accurate in males (who store most of their fat in their middles) but not females (who also store fat in their lower bodies)
- Bio-electric resistance (how well do you conduct electricity?)
    - Arm-to-leg bioelectrical impedance analysis (BIA) – goes foot-foot or foot-hand
        - Sends electrical signal through body: fat is not a good conductor but muscle is therefore the more impeded the signal is the fatter you are
        - Can't exercise, eat, drink, sleep before measurement for accuracy
        - Common in gyms – costs $20-$8000
- CPAFLA evaluation of body weight, adiposity and fat distribution

-Body composition:

- Genetics – ratio between estrogen:testosterone
- Female phenotype = pear shaped (fat predominantly stored around hips)
    - Gynoid: not associated with health risk factors
- Male phenotype = apple shaped (fat stored predominantly around the waist)
    - Android: enhances risk for high blood pressure, cardiovascular disease, diabetes, and abnormal blood lipids
    - Females start to take on this shape during menopause because their estrogen levels drop, increasing their cardiovascular risk

-Anthropometry: how thick you are (waist/hip circumference, sagittal diameter)

- Tension should be consistent for all measurements
- Sagittal diameter measures visceral fat (doesn't flatter when you lie down) and sub-Q fat

-Advantages of fat:

- Energy storage – mobilizes during activity to provide energy
    - Better than carbs, which you would have to store 20% more of to get the same energy
- Insulation
- Swimming – more buoyant, less heat loss (why long distance swimmers have more sub-Q fat)

- Appearance – would be very gaunt without any fat

-Disadvantages of too much fat:
- Associated with serious health risk
- Limits your PA because of inefficiency of movement, more accident prone because your centre of gravity is thrown off
- Extra stress on bones and joints (orthopaedic problems) – can actually change shape of bones
- Psychologically damaging – people judge you plus your self-esteem drops
- Ineffective in motor behaviours

-Body energy stores:
- Largest amount of energy stored in adipose tissue (fat) – 120 000 kcal
    - Can release fats into the blood to be used as energy by the muscles
- Energy stored in muscles as fats and sugars (energy here is trapped in the muscle, cannot be transferred from one muscle to another)
    - Muscle triglyceride and muscle glycogen
- Small amount of energy stored in the liver (liver triglyceride, liver glycogen) can be shot into the blood to be transferred where needed
    - Liver can package fats and create more sugars

<u>Obesity</u>

-In US, obesity = about 30% of population (very high in the Southern States), mid 20s% in Canada (in areas like the Territories)
- 1 in 4/5 Canadians have a weight problem

-Top 3 most obese countries: US (31%) > Mexico > UK; least obese countries = Korea (3%) > Japan (3%) > Norway; Canada = 14%

-Children getting more obese (boys slightly more than girls)
- Most overweight/obesity prevalence ranking in youth: Malta (1st), US (2nd), Canada (5th)
    - But Canadian youths are gaining weight at a faster rate than American ones
- Obesity in children considered neglect/abuse in some situations (being taken from their parents)
- Higher BMI seen in children = worse health problems as adults
    - 16% of children in highest category experience weight related issues in their early middle age, where this is almost unseen in leaner children

-Abdominal or visceral fat?
- Even though visceral fat (in your organs) only makes up 11.5% in men and 5% in women of your total fat, it is the strongest indicator of health risks
    - Why not all obese people have diabetes (even though their BMI may say they are obese they may not have that much visceral fat, though they are more likely to)
- Low visceral fat = low triglycerides = low cholesterol = better health (opposite when more visceral fat is present)
- There are no significant decreases in health risk factors with the removal of sub-Q fat alone (ex: liposuction – can't lipo visceral fat because it's in the organs)
    - Bigger waist circumference = more health risks within the same BMI

increased BMI + increased waist circumference = increased health risk
- Through diet and exercise you lose more visceral than sub-Q fat
    - Getting rid of what is associated with the most health risks

    - Losing 5-10% of your body weight when you're obese makes your metabolic profile healthy (even though your BMI is still high)

-Obesity caused by heredity or genetics? (nature vs. nurture)

- Overweight parents have overweight children - because of learned eating habits or genetics? Environment and genetics play a role:
    - Cultural influences: the type of food you eat (environment)
        - Bouchard – genetic contribution to obesity = 25-40%
    - Adopted children are more similar to their biological parents (genetics)
    - Some say it is prenatal programing
        - Recommended weight gain in pregnant mothers =
            - 12.5-18 kg with a BMI less than 20
            - 11.5-16 kg with a BMI between 20-27
            - 7-11.5 kg with a BMI greater than 27
        - Food increases by trimester:
            - 1st – 100 cal/day
            - 2nd – 200-250 cal/day
            - 3rd – 400-500 cal/day
        - Pregnant women who gained more than this were 4x more likely to have overweight children by the age of 3
            - Mothers pass dietary traits to children, environment in the womb programmed the child's BMI

-Medications for diabetes, corticosteroids, anti-psychotics, anti-depressants, antihypertensives, antihistamines, anticonvulsants can make you gain weight

- They still help you medically because they increase your sub-Q fat while your visceral fat in decreasing
    - Weight gain could be due to appetite, changes in metabolism, fluid retention

-Depression and weight gain

- Obese people 5-7x more likely to be depressed
    - Depression medication causes weight gain (20-25 lbs. in a month)
    - Medications that cause the greatest weight gain help the most with depression (though your self-esteem decreases)

-NEAT (non-exercise activity thermogenesis) affects energy balance

- Anything non-exercise related (ex: brushing your hair fidgeting)
- Obese people sit more and stand less
    - The amount of time spent sitting/standing does not change after obese people lose weight
- People who fidget more are more resistant to weight gain

-Modern conveniences are making people less active, contributing to weight gain

- About 114 cal/day or 12 lbs/year

-Other potential causes of obesity:

- Sleep deprivation, environment pollutants, increasing maternal age, prenatal stress, immigration, quitting smoking, assortative matting (you + your partner have the same body type), light exposure (too much, never fully dark), mental stress, central heating/cooling, global warming (more availability of food, warmer so you don't have to move as much to stay warm)

Diabetes

-Facts about diabetes:

- "Diabetes" was coined by Artetaeus of Cappadocia
    - Derived from *diabainein* meaning passing through (reference to excessive peeing)
    - In 1675 Willis added the word *mellitus* (honey) referencing the sweet taste of the pee
        - Many cultural names for diabetes include the similar references
- Highest % of people with diabetes are seen in people over the age of 50
- 4 types of diabetes:
    - Type 1 – Insulin Dependent (cannot produce insulin)
    - Type 2 – Non-insulin Dependent (adult-onset, insulin can't get to receptors)
    - Gestational – caused by excessive weight gain during pregnancy, resolves itself after birthing, increases your risk of developing Type 2 diabetes and baby's risk of getting diabetes
    - Secondary – pancreas is destroyed by some sort of drug

Type 1 Diabetes

- Pancreatic beta-cell failure (these cells that create insulin are attacked by the immune system which thinks they are a foreign entity) - not enough insulin is created as a result, glucose can't be brought to cells so they starve)
    - Occurs quickly (within months)
    - Environmentally triggered (maybe)
- Diagnoses generally before teenage years
- Requires insulin administration, frequent blood glucose monitoring, nutritional considerations
- Symptoms:
    - Unexplained rapid weight loss, ketosis (using fat for energy because there is no insulin to bring blood glucose to the cells), abdominal pain, nausea, vomiting, frequent urination, extreme thirst/hunger/fatigue

-Insulin:

- Before insulin, people with diabetes starved to death
- 1869 Langerhans noticed tissue clumps scattered throughout the pancreas and named them *Islets of Langerhans*
- 1889 – found surgical removal of pancreas resulted in diabetes
- Banting (U of T) with Best discovered insulin in 1921
- Patent for insulin was sold to U of T for $1

-In pancreas there are 2 types of cells - alpha and beta which both produce different hormones (in clumps these cells are called Islets of Langerhans)

- Beta-cells produce insulin (the hormone that controls blood glucose)
    - Release insulin into blood to allow glucose to enter the muscle

-How insulin works:

- On the surface of muscles are receptors that insulin attaches to in order to activate certain reactions.
    - These reactions "turn on" the glucose channels so that glucose can get into the muscle to be used or stored

-Before you eat, insulin levels are very low and blood glucose levels are at about 5mM (at rest)

- When you consume sugars the increase in your blood glucose levels is detected by the pancreas which releases insulin
    - Insulin levels go up to compensate for increased blood glucose levels which eventually drop back down, dropping the insulin levels with it (in about 2 hours for a normal person)
- If you have Type 1 diabetes:
    - Pancreas does not release insulin, reactions do not happen and glucose channels remain closed (glucose cannot get in, stays in blood until it is peed out)
        - Think - lots of locked doors but no keys

-Insulin injections help children with Type 1 diabetes gain weight

-With Type 1 diabetes, if you have higher fitness (exercise more) you will have:

- Better glucose control, reduced insulin requirement (makes insulin more effective in opening glucose receptors, some of which open without insulin just through exercise), increased functional capacity, increased lean mass, positive psychological effects, increased life expectancy
- Some risks of strenuous exercising with Type 1:
    - Post-exercise hypoglycemia (very low blood sugar) - from 3-31 hrs. after exercise
        - Shakiness, disorientation, seizures, loss of consciousness
        - Can be limited by decreasing insulin injected before exercise, increasing car intake before and during exercise

Secondary Diabetes

-Pancreas does not produce insulin because bets-cells have been destroyed

- By disease, medical conditions, medications
    - Ex: hemochromatosis, alcoholism, malnutrition, long-term steroid use, etc.

-People with this experience extreme thirst, weight loss, breath that smells like nail polish/sweet, constant urination

diabetes rates match up with obesity rates

Type 2 Diabetes

-Over 2 million Canadians have this

-Amount of people that have diagnosed diabetes = the amount that have undiagnosed diabetes

- Amount of people with borderline = the amount with diagnosed + undiagnosed diabetes

-When blood glucose levels go up there is a large amount of insulin however the insulin receptors aren't working properly (less insulin is going through, opening less glucose channels)

- In advanced stages of type 2 insulin production drops because the pancreas (which has been producing huge amount of insulin to try to open more glucose channels) burns out

-Risk factors:

- 40+, relatives have diabetes, anyone who isn't white, have history of impaired glucose tolerance (IGT or IFG), had a large baby, vascular disease, hypertension, dyslipidemia, overweight/obese, polycystic ovary syndrome

-Symptoms:

- Frequent urination/infections, extreme thirst/fatigue, blurred vision, slow to heal from cuts and bruises, tingling/numbness in hands and feet (advanced stages), dry itchy skin

-Long-term complications:

- Retinopathy: destroyed retinas (diabetes = leading cause of blindness)

- Diabetic neuropathy – leading cause of non-traumatic amputations, foot care = very important in diabetics
- Increases risk of heart attack/stroke by 2-3; 70%-80% of diabetics die of heart disease

-Diagnosis:

- 2 hour 45 gram Oral glucose challenge
    - Test blood 2 hours after drinking orange glucose drink
    - If your glucose levels are high then you could potentially have diabetes
        - Low insulin – type 1, regular insulin – type 2

-Treatment: (difficult for them to lose weight because they burn sugar instead of fat, can't achieve a normal body weight)

- Insulin/medication, weight loss (improves insulin sensitivity), diet of 60-70% carbs and monosaturated fats and high fibre (half plate veggies, quarter starch, quarter protein, a fruit, glass of milk), physical activity (150 min/week moderate or 90 min/week vigorous), resistance exercise (3x/week)
    - Resistance training and weight loss has considerably better effects on lowering blood glucose levels in people with diabetes than weight loss on its own
        - Same with combining aerobic and resistance exercises

-What happens after you reverse type 2 diabetes?

- Must maintain a proper weight/diet and met PA guidelines to show no signs of diabetes
    - If not, you could go into remission

-Lifestyle is better in preventing diabetes in people that are at risk (only 20% got in) than the medication metformin (30% got it)

Gestational Diabetes:

-Occurs in 4-7% of all pregnancies; during the 24^{th} week of pregnancy (is temporary)
-disappears within 6 weeks of delivery
-More common in obese women and women with a family history if type 2 diabetes
-Increases risk for type 2 diabetes in the future
-Diagnosis = 1 hour 50 g oral glucose challenge
-Consequences: baby has increased fat/body weight (up to 10-12lbs.), higher risk of miscarriage and birth defects if woman has diabetes before pregnancy
-Treatment: can't take medication so lifestyle changes need to be made (nutrition, calorie restriction in obese women, insulin, and moderate physical activity)

<u>Weight Control</u>

-Stable weight = equal caloric intake and expenditure
-Weight gain = overeating, sedentary living
-Weight loss = dieting/vigorous exercise separate = lose 0.5-0.75 lbs/week; together = lose 1-2 lbs/week
-Obese people: eat more/need to eat more the bigger you are

- Burn more calories doing the same exercise as someone lighter because they are carrying more weight

-Obesity treatment pyramid: first try diet and exercise, then pharmacotherapy, lastly surgery

- Most people try to lose weight through caloric and fat restrictions (dieting) instead of exercise, even fewer try diet and exercise together

-Satiety messengers to the brain:
- Grehlin molecule: stretch receptors in the stomach that take 20 mins to tell the brain you're full
    - Should eat meals in at least 20 mins so you don't over eat, traffic light fork can help with this
- Leptin hormone: fat cells that say you're full
    - Key in regulating appetite (decrease) and metabolism (increase)
    - Some people (very rare) are leptin deficient and are overweight as a result; given leptin they lose large amounts of weight
    - Obese people are leptin resistant (why they have to eat more to feel full)
- PYY hormone: stretch receptors in your intestines send message to the brain that says you're not hungry anymore (takes time) – causes feeling of fullness
    - Obese people secrete less of this than normal people
    - Given naturally results in 33% less food ingestion
        - Can be given as an injection
    - High fibre diets stimulate more PYY production

-Losing weight through dieting:
- Choose lower calorie foods that fill you up
- Take fibre pills (supposed to increase satiety and decrease Glycemic Index of food)
    - Has some side effects + is expensive; not clinically proven to work
- Use Diet and Healthy Eating plates (tells you how much of what to eat, are not too big)
    - We are trained to eat everything in front of us resulting in frequently overeating
    - We think we're full when were done what's on our plate and not before
        - Ex: bottomless soup bowl experiment
- Liquid diets replace food but have supplements, nutrients, etc.
    - About 230 kcal/drink
    - Good when you need to lose weight before surgery (hard to operate on large people)
    - Becomes difficult to self-regulate diet after coming off a liquid diet

-Association between obesity and food ad recognition:
- You eat more after seeing a food ad; the bigger you are, the more you eat
- Obese kids remembered the food ads better than lean kids

-Variety of food promotes overeating, regardless of hunger

-All foods can convert to fat:
- Takes 10-15% of energy to change carbs to fat; 2-3% of energy to convert fat to fat
- Some proteins are harder to convert to fat (lean protein) – these are the ones recommended in diets

-Pritikin (low fat) vs. Atkins (low carb, high protein – high saturated fat = high LDL) diets:
- Atkins results in more total weight loss over a short duration (less than 6 months)
    - However most of this is water loss
    - Rate very poorly in fibre and fruit/veggie consumption
        - Weight Watchers rated #1, Slim-fast #2 (both are pretty expensive)
- Dieting 12 months + there is no difference between the two diets in total weight loss
- People who lose weight on low fat diets have an easier time maintaining their weight

-Components of energy expenditure:
- 60-70% = RMR, 10% = thermic effect of food, 15-50% = NEAT,
    - Very small component = exercise-related activity thermogenesis (often negligible/0 in developed countries) ex: to burn 1 lb. of fat you need to lay 9 321 bricks

-Dieting results in more weight loss than fat loss; exercise results in even losses of both but in much smaller amounts than dieting (need to do a substantial amount of exercise to see any results), diet + exercise results in about the same amount of weight loss as dieting alone but a little more fat loss

-False: low-intensity fat burning exercise is the best way to lose weight (this uses a greater % of fat but does not burn as many calories)
- Since total caloric expenditure is the most important factor in weight loss, and/or the available time is limited, high intensity exercise is the best approach

-Body weight and caloric intake as a function of PA:
- Sedentary people = the heaviest, people who participate in light, medium, heavy, and very heavy types of work have very similar body weights
- Sedentary people eat the most, then people who exercise the heaviest to the lightest
    - Doing nothing (gain weight) and exercising hard (regulates body weight) make you hungry
    - Sedentary people have the same sized appetite as people who do moderate activity, people who do light activity have less of an appetite, and people who exercise vigorously have a larger appetite

-Resting energy expenditure:
- Burn more calories at rest after overeating
- Burn less calories at rest when underfeeding (your body is trying to defend its body weight)
    - Less thermic effect on food because there is less food
    - With weight loss, muscle mass decreases also decreasing the RMR (up to 20-30% if under and 800cal/day diet over 2-3 weeks)

-US getting fatter by 1.8-2 lb./year because of an extra 15 kcal/day

-Losing weight and gender:
- Since women have a lower fat free mass (FFM) than men at the same weight, men can burn more fat at rest and exercise more (are metabolically active as a result)
- Males store most fat centrally (easier to burn), female store most fat in the lower body (harder to burn)
- Women lose less weight than men for the same amount of exercise
    - Because of differences in appetite, or because women have less muscle mass and thus less energy expenditure
- RMR is 5-10% lower in women at same body weight of a man
    - Because of higher fat and lower FFM

<u>Prescription Weight Loss Drugs</u>

-Weight loss drugs can affect intake (appetite, absorption) or expenditure (ex: stimulants – associated with heart problems)

-Orlistat (Xenical)= only drug in Canada that will help you lose weight
- With a low fat diet this pill prevents fat from being absorbed because it is a lipase inhibitor
    - Triglycerides that are usually chopped up by lipase to be absorbed can no longer do so
- Can help you lose 5-10 pounds
- Side effects: frequent/uncontrollable bowel movements, diarrhea, stool leakage, cramps, bloating, flatulence
- Not covered by OHIP - $177.34 for 84 tablets (taken 2-3x/day)

-Subutrimine/Meridia (no longer on the market as of Oct. 2010) – an appetite control pill
- Reduces the reuptake of the neurotransmitters: serotonin, norepinephrine, dopamine
    - Increases the level of these in the synaptic clefts
- Very dangerous if taken by people with heart disease (why it was taken off the market)
- Side-effects: nausea, dry mouth, constipation, light-headedness, insomnia, increased HR/ blood pressure
- Cannot be taken with monoamine oxidase inhibitors (antidepressants)
- $168.57 for 30 tablets taken 1/day

-Fen Phen: appetite suppressant
- Pulled off the market because it was dangerous and people died
    - Messed with people's heart valves

-Liposuction:
- Used on thighs, abdomen, butt, hips
- Make a small incision for the suction cannula which is moved back and forth in fat layer
    - Removes fat from the deeper layer; if you remove fat from more superficial layers it will leave ridges
- Anyone with an M.D. can perform this procedure, usually done in clinics

-Laser liposuction:
- Laser light liquefies the fat before it is suctioned away, can seal damaged blood vessels to reduce bruising and swelling
    - Less invasive/risky/recovery time than normal lipo; carbon dioxide laser can tighten up loose skin
- Limited to smaller areas of the body: face, neck, arms, breasts
- Less expensive; no anesthesia needed

-Diet + exercise + medication = 15% max weight loss (hard to maintain)
- To lose more you need to have surgery – can give up to 25% weight loss and is easier to maintain

<u>Weight Loss Procedures</u>

-Jejunum-Ileum bypass:
- Part of the small and large intestine are bypassed
    - Decreases nutrient absorption and bile in small intestine (what absorbs fat)
- No longer done because it weight loss was so severe it caused liver damage

-Gastric banding (reversible, not covered by OHIP - $10 000):
- Keyhole surgery: band is tied around the stomach creating an unbalance hourglass shape with a small upper portion
- You feel full after eating much less than usual

- Band is balloon like and filled with saline which permits changes in the tightness of the band via a needle through an access port placed just below the skin
    - Ex: if you're pregnant, you need to open it up
    - If you eat too much it can cut into your stomach or slip out of place

-Gastric bypass (permanent, covered by OHIP – about $24 000):

- Food is delayed from mixing with bile pancreatic juices that aid in the absorption of nutrients
- Stomach = smaller (eat less), intestine = shorter (absorb less)
- Process:
    - Stapling creates a small stomach pouch
    - Remaining stomach is completely stapled and divided from the stomach pouch
    - Outlet of small stomach pouch empties into jejunum section of small intestine
- Gives best weight loss (25%)
- Fatality rate = 1 in 200
- Potential for bowel leakage and infection, blood clots, abdominal pains, depression
- Have to eat very small portions, very carefully for the rest of your life

-Gastric sleeve (more recent):

- Food intake is restricted (eat less) – almost as good as/can be the 1st step towards bypass
- Process:
    - About 60-80% of the rounded, larger part of the stomach is removed so that the remaining part of the stomach takes the shape of a tube or sleeve
    - The tube-shaped stomach is sealed closed with staples or sutures. The remaining portion of the stomach holds about 15% as much food as the original one

-Procedures are associated with hair loss because of caloric restrictions (you don't need it so your body gets rid of it)

-OHIP can't pay for all this so you need a BMI of at least 40 to qualify for surgery (but people getting to surgery are in the 60s, 70s and 80s), 160 000 people qualify in Ontario, 508 have had the surgery in 2006, 3500 people on the waiting list

-When you lose tons of weight you have excess skin (OHIP does not pay for skin reduction)

- Can get infection from this (skin rots)
- Need Limb Contouring surgery (cuts off excess skin)
    - More risky than actual bariatric surgery

-Possible physiological consequences of repeated cycles of weight loss and gain (yo-yo dieting):

- Increased preference for dietary fat/efficiency of fuel utilization (burn less calories)/ratio of total fat to lean mass/redistribution of fat to abdominal area/risk of heart disease and cancer, decreased metabolic rate

-Successful weight loss maintainers:

- Limit the intake of certain foods,
- Consume an average of 1400cal/day
    - 24% fat, 19% protein, 56% carbs
- Eat 5 times/day
- Burn an average of 2800 cal/week through exercise
    - 400cal/day or 60 min of walking at 15 min/mile

-68% of people say maintaining weight is more difficult than losing it in the first place

-75% of people weighed themselves at least once/week

Structure of Skeletal Muscle Fibre (Cell)

-Muscle: composed of many cell types: muscle, vascular, satellite - composed of:

- Fascicle: bundle of many muscle fibres (10-20 within a muscle) - composed of:
- Muscle fibre/cell (an elongated structure): and individual muscle cell composed of many myofibrils (cylinders where most of the protein is) which occupy the majority of the cell (about 85%) with mitochondria and internal membranes (sarcoplasmic reticulum, t-tubules) accounting for about 10% - composed of:
    - Myofibrils (within a muscle fibre): run the length of the muscle fibre (about 5000/muscle fibre) – repeating contractile units known as sarcomeres

-Sarcomere (or "contractile units of skeletal muscle"):

- Basic unit of a myofibril
- The number of sarcomeres in parallel determine the maximal force; the number in series determines the length excursion and shortening velocity
- Is usually 2.5mm long; there are about 40 000 sarcomeres in series in one muscle fibre that is 100 mm long
- Bracketed by two Z-lines
- H-band/zone = the empty region between proteins
- A-band has the highest protein density (looks dark), has both filaments in it
- I-band is from a thick filament on one sarcomere the a thick filament on another (less protein here) bracketing a Z-line
- M-line – in the middle of the sarcomere
- Major filaments associated with the sarcomere are the thick and thin filaments
    - Each thin filament is composed of an actin filament and is associated with regulatory contractile proteins (Tm, TnT, TnI, TnC)
        - Composed of "globular protein" (or G-actin) which comes together to form F-actin (which forms a filament)
        - Come out from the Z lines
    - Each thick filament is primarily composed of 300 native myosin molecules making up the myosin filament
        - 20-30 filaments/sarcomere
- Protein-protein interactions of filaments in skeletal muscle fibre:
    - One myosin molecule on the thick filament will interact with the actin filament at various regions (protein-protein interaction) causing a contraction
        - When there is a muscle contraction the sarcomere shortens and the proteins overlap
            - A-band/H-zone/M-zone stay the same, I-zone shortens
        - When the muscle relaxes, the sarcomere lengthens again

-Function of sarcomere and muscle fibre = contraction and force production:

- 2 proteins interact in a cycle:
    - Myosin molecule needs to be energized by ATP which breaks down (hydrolyzes) into ADP and P*i*, preparing the myosin site
    - If there isn't any calcium it remains energized; if there is calcium then there is an excitation and the two proteins bind together
        - ADP and P*i* come off as one protein moves along the other in a power stoke - must be expressed down the entire fibre
    - In the presence of fresh ATP there is a detachment of proteins

        - A lack of ATP results in a rigor complex (no detachment of proteins) which is associated with death
- Control Features… need:
    - Calcium > affected by training
        - Release and removal of calcium is a cycle
            - A nerve comes down exciting the motor end plate > an action potential goes down into the internal tubules > activates the release of calcium > prepares the actin for interaction with the myosin to form the contraction > calcium is removed back up through the cycle where reuptake is done by the sarcoplasmic reticulum
                - Muscle cannot relax unless the calcium is removed
    - Energy – ATP > affected by training
    - Mechano-transduction through protein-proteins interactions > affected by age/disease
        - Tension produced when actin and myosin come together

-Relationship among energy systems in skeletal muscle (need ATP to energize the myosin molecule)

- Can get energy (ATP) from internal muscle stores – the Creatine kinase system which uses phosphocreatine (PCr) to generate more ATP
- Can get energy from glycolysis
- Can get energy from an externally supported energy source - the cardiovascular system - get a lot of ATP from here; oxygen must come in while carbon dioxide must go out

-Proteins that help with the functioning of the sarcomere (stability and transmission of force):

- Desmin (attaches Z line – Z line) aligns the fibrils so force is expressed along the fibre
    - 53 kDa
    - Circles periphery of Z line
    - Functions: links Z lines of neighbouring myofibrils, integrates the contractile apparatus with sarcolemma and nucleus (so fibrils work in time with the entire sarcomere)
    - Desmin failures = myofibrillar and desmin myopathies
- Titin – protein that extends from the Z to the M line, 3000-4000 kDa
    - 244 protein domains (different specialized regions)
    - Function: force transmission at Z line, resting tension at I band, contributes to active stiffness, adhesion template – scaffold (other proteins, etc. like to stick to it)
    - Types: cardiac, skeletal
- Alpha-actinin (protein in Z lines) binds actin to the Z line, 97 kDa
    - Arranged in pairs in antiparallel direction in Z line (heads on top of tails & vice versa)
    - Function: form a strong complex with F-actin, anchor the actin filament
    - Types: type 2 – present in all muscle types; type 3
- Creatine kinase (M line)
- C proteins (MYBPC), 140 kDa
    - Located in the middle 1/3 of each half of A band
    - Functions: binds to myosin tail region, bands around the myosin filaments keeping them in bundles of 200-400 molecules

    - Types: slow (MYBPC1), fast (MYBPC2), cardiac (MYBPC3)
    - If C-protein fails and the myosin unravels, cardiac muscle can become damaged ("cardiomyopathies")

-Myofibril protein-protein modifications – protein turnover and breakdown

- When proteins are synthesized, hypertrophy increases
- Clinically important in the diagnostic assessments of the blood
    - Used to see what's happening to the muscle as a result of disease, exercise, etc.
    - Can assess degree of muscle damage

<u>Linking Muscle Structure to Muscle Function</u>

-Work = force x distance

-Power = work/time

-Units of measurement: force (N), time (s), work (J), power (W), mass (kg), distance (m), velocity (m/s), torque (N·m)

-Force production in the SARCOMERE is dependent on:

- How many sarcomeres are involved in a contraction
    - The greater the number of sarcomeres (myofibrils), the greater the contraction force
        - Cross-sectional area of a muscle is a good indication of "physiological strength"
- How the sarcomere proteins interact – complex
    - Length of the sarcomere (number if actin-myosin bridges formed per sarcomere)
        - Maximal force production occurs between 80%-120% of resting sarcomere length (2 um +/- 20%), force drops if the sarcomere is too long/too short
            - Due to spacial relationship between actin and myosin (work best at a certain distance from each other)
    - The type/quality of the protein (velocity/speed of the contraction)
        - Contraction velocity is dependent on the type of myosin (slow/fast)
        - Increases velocity = decreased force potential
            - If actin and myosin move too quickly, they can't do a good job
        - Power-velocity relationship = inverted U shape
            - A middling velocity produces the most power (trade-off between force and velocity)

-Force production in the MUSCLE is dependent on:

- Types of contractions
    - Most force to least force produced = eccentric (muscle lengthens) > isometric (muscle doesn't change in length) > concentric (muscle shortens)
        - Lengthening: I-band, H-zone, sarcomere all increase in length
        - Eccentric produces the greatest force because titin protein plays the largest role here, preventing the muscle from over-lengthening
- Contractile speed
    - Sarcomere
    - Type of myosin, **Associated energy system**
        - Type 1/Slow (S), **slow oxidative fibres (SO)**
            - Slower contracting

        - Fatigue resistant (uses ATP slowly)
        - Ex: muscle fibres used to maintain posture
    - Type 2a/Fast: Fatigues Resistant (FR), **fast oxidative fibres (FOG)**
        - Faster contracting (use ATP quickly)
        - Moderate resistance to fatigue
        - Ex: muscle fibres used for non-exertive movement (walking)
    - Type 2x/Fast: Fast Fatiguing (FF), **fast glycolytic fibres (FG)**
        - Fastest contracting (uses ATP quickly)
        - Easily fatigued
        - Ex: muscle fibres used for powerful movements (jumping)

  *For a given rate of shortening (velocity), high Vmax muscle fibres (Type 2) produce more force and power
- Sarcoplasmic reticulum calcium release into and removal from the cytoplasm

- Bio-energetics (energy processes: the rate of supply and the capacity for energy generation)
    - Type 2 muscle fibres use more energy at a faster rate
        - Amount of ATP produced is dependent on energy use because the demand and supply are relatively even (can never over-supply ATP, only produces what is used)
- Neural elements
    - Alpha-motor neurons/unit (number of fibres may vary)
        - The more neurons there are, the greater the force produced
    - Motor unit pool (many motor units of different types)
        - The more motor units that contract, the greater the force produced
- Stimulus strength
    - As a neuron is sending impulses, a certain threshold needs to be reached in order to start an action potential
        - After a threshold has been reached, contraction does not increase with more stimulus
- Stimulus frequency
    - More frequent = more instances of force production
    - Least to most frequent = twitch > summation > incomplete tetanus > complete tetanus (so frequent, force appears to be constant)
    - A higher frequency of stimulation is necessary to produce the same relative force in a fast vs. slow muscle/motor unit
        - At lower frequencies, slow muscle fibres (Type 1)/smaller motor units produce more force, are recruited earlier and max out 1st compared to fast muscle fibres (Type 2)/larger motor units which fire later and are associated with greater F generation

<u>Bioenergetics and Muscle Metabolism</u>

-Bioenergetics: the flow of energy in a biological system resulting in the ability to do work

-Thermodynamics: energy neither created or destroyed

- Types: thermal, chemical, mechanical, electrical, radiant, atomic/nuclear
- Exergonic reactions = energy releasing, negative ΔG
- Endergonic reactions = energy consuming, positive ΔG

-Enzyme catalyzed chemical reactions:
- Catabolic: breakdown of larger molecules into smaller ones
- Anabolic: synthesis of larger molecules from smaller ones

-Metabolic pathway – metabolism:
- Total of all the catabolic/exergonic and anabolic/endergonic reactions in a system
- Ex: glycolysis – associated with a ΔG of -642 kcal/mol (a large release of energy)

-ATP: intermediate high energy phosphate containing molecule (ΔG of -7.3 kcal/mol)
- Allows for the transfer of energy from exergonic to endergonic enzyme catalyzed/facilitated chemical reactions
- With contraction, the Myosin ATPase hydrolyzes the ATP molecule so energy is released for 25% mechanical movement while 75% is released as heat (rxn is only 25% efficient)
    - ATP + water → ADP + P*i* + H ion + heat energy
        - The mechanical energy that is released here goes to binding the actin and myosin and producing a force
            - As this continues, ATP must be regenerated

-Energy systems used to replenish ATP:
- Phosphagen (immediate: 0-6 seconds)
    - Occurs in the sarcoplasm
    - Does not require oxygen (anaerobic energy system)
    - ATP + water → ADP + P*i* + H ion + heat energy (one way reaction)
        - Creatine kinase takes ADP + H ion (products of above) to produce ATP
        - ADP + P*i* + H ion + heat energy ↔ ATP + CR
            - ATP can then be used to fuel the first reaction (immediate energy)
            - There is a limited amount of PCr (enough to last 7-8 s)
            - When PCr runs out ATP and AMP builds up
                - AMP build up alerts the body that a different energy supply needs to be used – stimulates glycolysis
                    - 2ADP → ATP + AMP
- Glycolysis – breakdown of carbs (6-180 seconds)
    - Occurs in the sarcoplasm
    - An anaerobic or aerobic energy system (requires some oxygen)
    - 1st substrate = glucose-6-phosphate ↔ fructose-6-phosphate (ATP is needed, catalyst = phosphofructokinase-1, NAD required – redox reaction: picks up H to be released as NADH in the next step) → two 3-carbon sugars → fructose-1,6-bisphosphate (2 NADH released, 4 ATP released – 2 from each 3-carbon sugar) → pyruvate = final substrate
        - phosphofructokinase-1 = allosteric (responds to shifts), the rate controlling enzyme (dependant on AMP) – controls how fast glucose-6-phosphate will go to pyruvate

1) Anaerobic glycolysis:
    - Glucose-6-phosphate comes from muscle glycogen (catalyst = glycogen phosphorilase)
        - Glycogen phosphorilase decreases when PA intensity increases [rate controlled by epinephrine (increases it) and insulin (decreases it)]
            - Low glycogen levels result in using blood glucose to produce glucose-6-phosphate (start of aerobic glycolysis)

- Pyruvate produces muscle lactate, reaction requires NADH (resulting NAD cycles back into glycolysis), LDH = the catalyst
  - LDH increases when PA increases, producing more lactate

Factors determining anaerobic glycolysis

- Capacity:
  - Concentration of muscle glycogen
  - Concentration of muscle lactate (related to type of enzyme LDH)
  - Sufficient NAD → NADH
- Rate:
  - Activity of PFK (phosphofructokinase)

2) Aerobic glycolysis:
   - Glucose-6-phosphate comes from blood glucose (catalyst = hexokinase)
     - Huge amounts of blood glucose are stored in the liver
   - Pyruvate produces Acetyl CoA through mitochondria (1st substrate in aerobic metabolism) with the support of CoA, NADH, and AMP

Factors determining capacity for aerobic glycolysis

- Blood glucose entry to muscle cells
  - Calcium with contractions
  - Insulin
- Pyruvate into mitochondria
  - Primarily high PDH (pyruvate dehydrogenase) activity
    - Increased NADH and AMP
    - Sufficient CoA
  - Availability of oxygen

- Oxidative Phosphorylation/Aerobic Metabolism (180 seconds +)
  - Primary source of energy at rest and low-intensity, uses carbs and fats as substrates
  - Occurs in the mitochondria
  - An aerobic energy system
  - Consists of 2 groups of enzymes within the mitochondria: Tricarboxylic Acid Cycle (TCA) and electron transport chain (ETC)
  - Pyruvate > Acetyl CoA (1st substrate of TCA, can come from carbs, fats or proteins) > TCA (generates NADH, which will become the 1st substrate of the ETC, as it metabolizes Acetyl CoA) > NADH > ETC [consists of a number of enzymes located on the inner mitochondrial membrane, moves electrons (H+ from NADH from TCA and glycolysis) from the mitochondria into its inner membrane]
    - There is a requirement for oxygen (last acceptor of H+ from ETC to make water) and the removal of carbon dioxide produced in the TCA
    - ATP synthase produces ATP by adding ADP + P*i*
      - Able to happen through the reuptake of the H ions that were pumped out during the ETC

Factors determining capacity and rate of aerobic metabolism

- Rate (mitochondria) of making ATP
  - Isocitrate dehydrogenase (and enzyme in the TCA)
  - ATP demand/requirement (as determined by the myosin ATPase)

- Capacity (mitochondria) to make ATP
  - Concentration of Acetyl CoA
  - Cytochrome C (an ETC enzyme)
  - Oxygen concentration
- Capacity (muscle) to make ATP
  - % of type 1 fibres (more type 1 = greater capacity)
  - Volume of mitochondria (more mitochondrial muscle = greater capacity)
  - Blood flow (vessels)

**all 3 energy systems are active at any given time; the extent to which each is used depends primarily on the intensity/power output/work rate of the activity and secondarily on its duration