BMSN1601 – Anatomy

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| What is Cardiovascular System |

* Through Hemodynamics 🡪 Deeper understanding in Cardiovascular System
  + Hemodynamics = Study of Blood flow by physical methods
  + Visualization of Hemodynamics can be done by 3D MRI

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| Introduction to definition of CO, HR, SV, Q and BP |

* CO is Cardiac Output
  + Amount of blood pumped by **each ventricle** in **1 minute**
* HR is Heart Rate
  + Number of Heart beat in 1 minute
* SV is Stroke Volume
  + Volume of Blood Pumped out by **a ventricle** with each beat.
* Q is Blood Flow
  + Volume of blood flowing through a vessel, an organ or the entire circulation in each period
* BP is Blood Pressure
  + Force per unit area exerted on the wall of a blood vessel by its contained blood.
    - Like e.m.f 🡪 Provide Driving Force to the Blood
  + Unit: mmHg
  + Site of measurement: **brachial artery** (large arteries near the heart)

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| 💥 | Blood Flow is not equivalent to the Cardiac Output.  Blood Flow in the entire circulation per minute = Cardiac Output. |

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| Introduction to Blood Pressure |

* Difference in BP within vascular system 🡪 Driving force to blood 🡪 Blood Flows
  + From High Pressure to Low Pressure Area
  + Aorta (大動脈) 🡪 Arteries (動脈) 🡪 Arterioles (小動脈) 🡪 Capillaries (毛細血管)   
    🡪 Venules (小靜脈) 🡪 Veins (靜脈) 🡪 Venae Cava (大靜脈)
* Arterial Blood Pressure – Systolic Pressure
  + Arterial Pressure **during ventricular contraction**
* Arterial Blood Pressure – Diastolic Pressure
  + Arterial Pressure **during ventricular filling**
* Pulse Pressure
* Mean Arterial Pressure
  + Average arterial pressure during **a single cardiac cycle**.

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| 💦 | Examination Technique:  Systolic Pressure @ Highest Level in cardiac cycle  Diastolic Pressure @ Lowest Level in cardiac cycle |

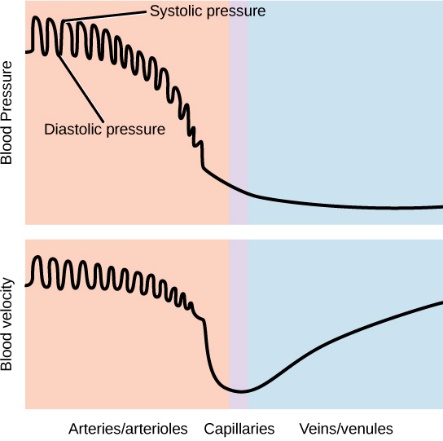
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| The Common Formula For Cardiovascular System |

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| Entire Circulation Formula: |
| #Blood circulation Formula:  #:The Formula is similar to the Ohm’s Law, where |
| Formula for velocity of Q:  \* The Formula is assume that there is no resistance in the blood vessel  \* Important Idea: Current in = Current Out, when there is no branches, the blood flow will always be the same |
| Poiseuille’s Law:  \* Regulation of blood vessel radius  \* is not subject to **significant short-term regulation**, in other word, t cannot  \* and not subject to **significant regulation** by body, where t cannot 0   |  |  | | --- | --- | | ❔ | * Do notice that the Blood Pressure decrease over the time   + From Aorta to Venae Cava * There is no change in the radius of blood vessel within the length L * Smaller the radius, Larger the Resistance, Smaller the speed.   + Do compare this relationship with the above formula , where the above formula omit the resistance. – For Detailed Information, Plz Refer to the next page | |

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| Poiseuille’s Law v.s. Q-v Formula |

* Poiseuille’s Law can only be applied when is not significant.
* Q-v Formula can only be applied when there is no resistance

*According to the Following Graph:*



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| * Do notice that the in Aorta (大動脈), Arteries (動脈) are significant.   + The formula cannot be applied because the heart keeps bumping bloods (keep doing work on the blood flow) to against the resistant.  🡪 The force acted by resistance on the blood flow is not constant (tends to zero). 🡪 The Q (Blood Flow) tends to be unchanged. 🡪 Thus, the velocity of fluid cannot be found by the Poiseuille’s Law * Q-v Formula should be applied in Aorta and Arteries, where the resistance is tends to zero due to the effect of bumping of heart. * That’s why the beginning of velocity of fluid is tends to unchanged.   **We have , Larger the radius, Lower the Velocity of Fluid.** |

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| * Do notice that the in each region of Arterioles, Capillaries and veins/venules **are not significant.** * However, it is far apart from the heart, **the resistance cannot be cancelled by the work done by heart**.   + The Resistance is significant & Lots of Branches 🡪 Thus, the **Q is not constant** and **Q-v formula cannot be applied.** * We should applied Poiseuille’s Law in those cases.   + We have: and * Region Arterioles & Capillaries   + **Smaller the Radius, Lower the Velocity of Fluid.** * Region Venules (小靜脈) ,Veins (靜脈) ,Venae Cava (大靜脈)   + **Larger the Radius, Higher the Velocity of Fluid.**   + The Blood Flow is gradually increased from Venules to Venae Cava. |

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| ❗ | There is no direct relationship between velocity of blood, blood pressure and blood flow. |

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| Blood Vessel – Laminar Flow & Turbulent Flow |

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| Laminar Flow |
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| * Requirement:   + Fluid flows in layers parallel to vessel wall   + Without disruption between layers * #Characteristic:   + **The layer of fluid in contact with the wall has lower velocity**   + **The layer of fluid that moves along the axis of the tube has maximal velocity**   #: This can be explained by the resistance act on the layer of fluid in contact with the wall |

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| Problematic: Turbulent flow | |
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| * Requirement:   + Irregular Movement * Characteristic:   + Q is decreased 🡪 Heart Need to Bump more vigorously 🡪 Great Work load   + v is decreased | |

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| Some Example to demonstrate the importance of Hemodynamics |

图示

描述已自动生成

* Hypertension / Hypotension
* Stroke
* Aneurysms 🡪 Enlargement of an artery 🡪 Thin artery wall. 🡪 Risk of Apoplexy (内出血) / Intracranial bleed (腦出血)

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| Introduction to Respiratory System |

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| Upper Tract | * **Filter & humidify incoming air** | **Nose** |
| **Pharynx** |
| Frontal Sinus |
| Sphenoidal Sinus |
| Nasal Cavity |
| Internal Nares |
| Lower Tract | * + **Delicate conduction passages**  (精緻的傳導通道)   + **Gas Exchange – Refer to Respiratory Zone** | **Larynx** |
| **Trachea** |
| **Bronchi** |
| **Lung** |
| Bronchioles |
| Diaphragm |
| Alveoli |

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| Zone in Respiratory System |

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| **Conducting Zone**   * Provide Rigid conduits for air to reach Respiratory Zone | | | | | |
| Nose | Pharynx | Frontal Sinus | Sphenoidal Sinus | Nasal Cavity | Internal Nares |
| Larynx | | Trachea | | Bronchi | |

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| **Respiratory Zone**   * Site of Gas Exchange | | | |
| Bronchioles | Alveolar Ducts | Alveoli | Alveolar Sac |

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| **Respiratory muscle**   * Promote ventilation |
| Diaphragm |

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| Terms used in Respiratory System |

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| * Respiratory System   + To supply the body with O2   + To dispose of CO2 * Pulmonary ventilation   + Movement of air into & out lungs * Transportation   + Transport of CO2 and O2: Lung & Blood | * External Respiration   + Gas Exchange (GE): lung & blood * Internal Respiration   + GE: systemic blood vessels & tissues * Inspiration (inhalation)   + Air flows into the lungs * Expiration (exhalation)   + Gases exit the lungs |

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| Gas Law & Atmospheric Pressure & Unit for Pressure |

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| * 1 mmHg = Pressure generated by a column of mercury 1mm high * Atmospheric Pressure = 760 mmHg |
| * Delton’s Law   + Formula:   + By this formula, we can calculate the partial pressure by specific gas molecule * Fick’s Law of Diffusion   + Formula:     - k: Diffusion Constant (Solubility of Gas & Temperature)     - A: Area for gas exchange     - : difference in partial pressure of gas on either side     - D: Thickness of barrier to diffusion * Boyle’s Law / Ideal Gas Law   + Formula: , where k is constant |

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| Introduction to Pressure and Respiratory System (Inhalation) |

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| 🌹 | Important Note:   * Intrapulmonary Pressure Always equalizes itself with atmospheric pressure eventually * The Surface Tension = -1 \* Intrapleural Pressure (Pressure within the pleural cavity)   + Where the surface tension is the collapsing pressure of lungs. * **Intrapulmonary Pressure is always higher than Intrapleural pressure** |

* The Diaphragm contracts (變高)  
  🡪 Thoracic cavity increase 🡪 Intrapulmonary Pressure (Pressure within alveoli) Decrease
* The Rib Cage elevation (變肥)  
  🡪 Thoracic cavity increase 🡪 Intrapulmonary Pressure Decrease
* Intrapulmonary Pressure < 1atm / 760mmHg 🡪 Air Flows in

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| Mechanism of Exhalation |

* The Diaphragm relaxes (變矮)  
  🡪 Thoracic Cavity increase 🡪 Intrapulmonary Pressure Increase
* The Rib Cage Lowering (變瘦)  
  🡪 Thoracic Cavity Increase 🡪 Intrapulmonary Pressure Increase
* Intrapulmonary Pressure > 1atm/ 760mmHg 🡪 Air Flow out.

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| Pulmonary Function Test – Spirometer |

* Spirometer: Measure the **volume & rate** of air during inhalation & exhalation

1. A hollow bell is inverted over water
2. Bell is displaced as patient breathes into a connecting mouthpiece
3. A graph is plotted on a rotating drum

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| Concept of Homeostasis |

* Homeostasis = The Maintenance of a stable **internal** environment in the body
  + Internal Environment = Surrounds each living cells in the body / ECF
    - ECF = Interstitial Fluid + Blood Plasma

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| 🥩 | ICF: Intracellular Fluid / ECF: Extracellular fluid   * Cells undergo most vital biochemical reactions in ICF. * Substances are moved between ICF and ECF.   Interstitial Fluid: Lies between the cells  Blood Plasma: Liquid Matrix of Blood |

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| Properties of the internal environment |

表格

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| Physical Properties | Blood Pressure |
| Volume of ECF / Blood |
| Body Core Temperature |
| Chemical Properties | ECF, Concentration of ions |
| pH Level of Blood |
| Blood Glucose Level |
| Blood O2 and CO2 level |

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| Summary of Function of Organ System |

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| Nervous and endocrine systems | * Regulate body functions. |
| Integumentary system | * Forms a protective boundary around the body * Regulates body temperature |
| Musculoskeletal system | * provides support and body movement * Produces blood cells (Bone marrow) |
| Circulatory / Cardiovascular system | * Distributes materials by pumping blood |
| Respiratory system | Exchanging materials between the internal and external environment:   * Oxygen & Carbon dioxide |
| Digestive system | Exchanging materials between the internal and external environment:   * Nutrients & Water |
| Urinary system | Exchanging materials between the internal and external environment:   * Water and Waste |

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| Detailed Summary of Function of Organ System |

图形用户界面, 文本, 应用程序, 电子邮件

描述已自动生成

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| Fluctuation & Imbalance of Homeostasis |

图形用户界面

描述已自动生成

* Variables stay within a narrow range at all time
* Variables may change quite significantly throughout the day.

🡪 **If these variables become higher or lower than normal range, body acts to restore them to a “set point”**

* Some disease can be caused by **Imbalance of Homeostasis**
  + *Diabetes*
  + *Hypertension or Hypotension* （高血壓、低血壓）
* The disease involve failure of more than one organ system 🡪 It can be lethal.

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| **Summary of the concept of homeostasis** |
| * Homeostasis is about maintaining stable physical / chemical properties of internal environment (extracellular fluid). * Homeostatic control systems (sensor, control centre and effector) maintain regulated variable within predictable range. * Mechanism of control: neural, endocrine and neuroendocrine * Essential for survival and good health. * Some abnormalities in physiological variables are tolerated short-term, but are lethal in long run |

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| Homeostatic control system - Sensors |

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| **Sensors** |
| * Body has several sensors to monitor regulated variable  |  |  |  | | --- | --- | --- | | *Sensory Cell* | Thermoreceptor | Monitor the absolute/relative change in temperature. | | Baroreceptor | Monitor the blood pressure | | Chemoreceptors | Monitor the O2 and CO2 and Blood pH value | | Osmoreceptors | Monitor the **Osmotic pressure**   * Detect Hypertonic / Hypotonic | | *Cellular Component* | Cell surface receptors |  | | Enzymes |  |      * Then, The Sensors are sending signals to Control Center / Integrating Center |

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| Homeostatic control system – Control Center |

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| Control Center / Integrating Center |
| * The Control Center (CC) integrate **Signals from Sensors** * Then, CC use *electrical signals,**chemical signals*   (Usually both signals send to the effector 🡪 Maintain the homeostasis)   |  |  | | --- | --- | | Common Type of Chemical Signals | | | Neurotransmitter | Neuron or effector cell in close proximity to (靠近) site of neurotransmitter release | | Endocrine agent (hormone) | Target cells in distant places in the body | | Paracrine agent | Target cells in close proximity to site of release of paracrine agent | | Autocrine agent | **Autocrine agent acts on the same cell** that secreted the agent | |

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| Homeostatic control system – Effectors |

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| Effectors |
| * Effectors are the organs/tissues that determine the regulated variable   + Liver, Adipose tissue, Skeletal Muscle 🡪 Blood Glucose Level   + Kidney, Blood Vessel 🡪 Blood Volume and osmolarity |

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| Control mechanism -- Neural mechanism & [Endocrine / Neuroendocrine mechanisms] |

* Neural Mechanism
  + Sensory cells send signal to the central nervous system (CNS) via afferent neural (sensory neurons)
  + CNS send signal to effector via efferent neural (motor neurons)
  + Signal Transmitted are in the form of:
    - Neurotransmitters
    - electrical signal (action potentials 電勢 ).
* Endocrine mechanism
  + Change in regulated variable 🡪 Stimulate endocrine gland 🡪 Secrete Hormones 🡪 Circulation
    - Through Circulation, hormone reach the target cells / tissues
* Neuroendocrine Mechanism
  + Endocrine Gland Receive signal from efferent neural pathway
    - Secrete Hormones 🡪 Circulation 🡪 Hormone Reach Target Cell/ Tissues

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| ⛅ | Neural Mechanism v.s. Endocrine/Neuroendocrine Mechanism   |  |  |  |  | | --- | --- | --- | --- | |  | Speed | Specificity | Duration of Action | | Neural | Immediate response | Localized Effects | Usually very short | | Endocrine  Neuroendocrine | Slower than neural | Global Effect | Last Longer than neural | |

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| Negative Feedback Loop |

* Homeostasis is driven by negative feedback loop.
  + A disturbance to the internal environment   
    → Effector acts to change the regulated variable towards normal levels  
    → **Eliminates the stimulus detected by the sensor** ⇒ Negative
  + It can reduce the variability of a regulated variable ⇒ Negative feedback loops are self-limited
* Some Example of Negative Feedback Loop:

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| Baroreceptors are activated when blood pressure rises. This causes them to fire action potentials more frequently along the afferent neural pathway to the medulla oblongata(延髓).   The medulla oblongata reduces the amount of action potentials sent via sympathetic nerve(交感神經), while promoting action potentials sent via parasympathetic nerve(副交感神经).   These together cause the heart to beat slower and contract with less force, decreasing blood pressure |
| β-cells of pancreatic islet are activated when blood glucose level rises in fed state.  Then, the rate of glycolysis is increased by the increase in the concentration of glucose. As a result, is increased. At the same time, the secretion of insulin is also activated.  The insulin in the blood vessel → Liver / Adipose Tissue (脂肪) / Skeletal muscle increase the glucose uptake. Thus, the blood glucose level is then decreased and back to normal level. |

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| Positive Feedback Loop |

* Non-homeostatic physiological functions are driven by positive feedback loops
  + **Positive feedback loops amplify the input signal**
* Example:
  + Coagulation cascade (blood clotting – activation of clotting factors)

图示

描述已自动生成

* + Childbirth – oxytocin induces uterine contraction
  + Generation of nerve impulses

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| Feedforward Control |

* Variation of “other variable” directly compensates the anticipated (預計) changes in the controlled variable (independent of a sensor for the controlled variable)

图示

描述已自动生成

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| Example: Blood potassium level Regulation  Dietary potassium is sensed by potassium sensors in the gastrointestinal tract in the absence of changes in plasma potassium → Sensor anticipates changes → prompt the system to act in advance |

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| Circadian variation (昼夜节律) of physiological parameters |

* Circadian rhythm follows a 24h light-dark cycle
  + - Central nervous system receives input from eyes → influence various organ systems.
  + Example:
    - Body Temperature
    - Plasma Growth Hormone
    - Plasma Cortisol
    - Urinary excretion of ions