

獸醫生理學 第一講 代謝(**metabolism**)與生物能量學(**bioenergetics**)

(參考：獸醫解剖生理學(中) pp.99-102)

一。 Definitions of the metabolism / internal respiration

1.The utilization of nutrients by the **cell**, consisting essentially of **oxidation*** of carbon compounds to carbon dioxide and water with the release of **ENERGY**.

-----This is not like burning but is slow, controlled, **stepwise process**.

*Oxidation not only includes the addition of oxygen but also refers to **the removal of hydrogen / electrons**.

2.Metabolism refers to **the sum of the biochemical reactions** occurring in each **cell**. Those reactions that **build and maintain the body** through **energy*formation** are called **anabolic** and those reactions that **release energy** by the breakdown of substances are called **catabolic**.

*(1)The animals obtain this energy **directly** if they are **herbivorous**, or **indirectly** if they are **carnivorous**.

*(2)This energy is temporarily stored in the form of so-called '**high energy bonds**', which link **phosphorus** and **oxygen** atoms in adenosine triphosphate (ATP).

二。 Further explanation of the relationship of cell and energy

1.Cell can obtain the energy

(1)能量非源自創造，而是由一種 chemicals 移轉為另一種 currency。

(2)它的最佳受質(substrate)是 **glucose***與 **fatty acid***

*它們並不是被用來製成 ATP，而是在涉及之化學反應中，將 ADP 轉化為 ATP，最後再將能量移轉出來。

2.Cell can store the energy

(1)ATP 是一個高堤勢(high bank balance)：可直接釋出能量

(2)ADP 是一個低堤勢(low bank balance)：必需先**加高**(賦予能量)成為之後，才能作出進一步之**釋能**行為。

二。 Further explanation of the relationship of cell and energy (continue)

3. Linkage reaction of muscle constriction and restoration

$\text{ATP} \rightarrow \text{ADP} + \text{H}_3\text{PO}_4 + \text{Energy}$ 立即使用

$\text{CP} \rightarrow \text{creatine} + \text{H}_3\text{PO}_4 + \text{Energy}$ 自 ADP 再合成 ATP 之用

$\text{Glycogen} \rightarrow \text{lactic acid} + \text{Energy}$ 自 creatine 與 phosp 合成 CP 之用
(anaerobic glycolysis)

$\frac{1}{5} \text{Lactic acid} + \text{O}_2 \rightarrow \text{H}_2\text{O} + \text{CO}_2 + \text{Energy}$
(使其餘 $\frac{4}{5}$ 乳酸再合成 glycogen 之用)

思考區間(thinking compartment)

(1) 就 **chemical energy*** (metabolic **fuel**) 中之各類受質相對於現實社會中之流通物品^{*}進行概念配對：

* amino acid / ATP / CHO(glycogen) / CP / fatty acid / glucose

* cash / check(chèque) / credit card / passbook(deposit)

(2) **Brain** metabolism (BBB) — glucose / amino acid (gluconeogenesis)

三。 Basal metabolism and its related ideas

1. 體型大的動物較不易被環境控制：

體型愈大，單位體積之表面積愈小，而經由表面被環境影響的程度也愈小。

2. 體型大的動物較耐乾旱：

由體表流失的水分相對減少。

3. 體型大的動物較耐飢餓：

以平均體重的能量消耗而言，體型大者的消耗較小。

三。 Basal metabolism and its related ideas (continue)

4. 體型大小與能量消耗

$$\log E_s = \log 4.1 + 0.751 \times \log W \quad / \quad E_s = 4.1 W^{3/4}$$

E_s 代表基礎代謝量(單位是瓦特)， W 代表體重(單位公斤)。

若體積增加成 2 倍，能量消耗為 1.68 倍

// 100	" 32
// 10,000	" 1,000

思考區間(thinking compartment)

(1) 就大象(假設體重 4 ton) 與小鼠(40g) 進行比較：

重量比：100,000 / 1

能量消耗比：？

(2) 平均體重的耗氧量 = 個體的耗氧量 / 體重 = $4.1 W^{3/4} / W^1 = 4.1 W^{-1/4}$

當體重增加時，氧消耗如何？

四。 The connection existed between the endocrine system and metabolism

1. 管制能量代謝(energy metabolism)

包括：Insulin, Glucagon, Cortisol, Epinephrine, Thyroid hormone

2. 管制礦質代謝(mineral metabolism)

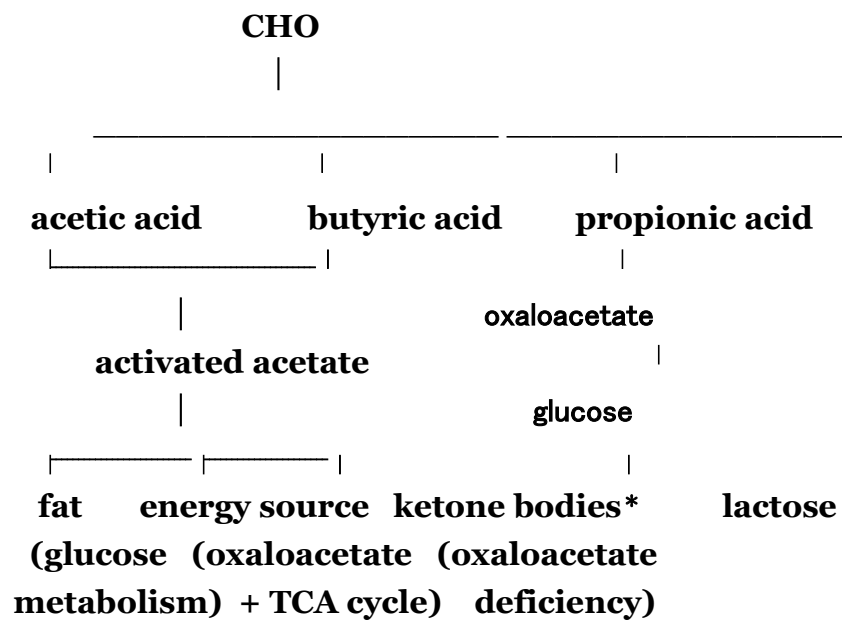
包括：Parathyroid hormone, calcitonin, Angiotensin, Renin

3. 管制生長(growth)

包括：Growth hormone, Thyroid hormone, Insulin, Estrogen, Androgen, many Growth Factors

五。 Clinical Review

1. Ketosis



* β – hydroxybutyric acid, acetoacetate, acetone.

2. Milk fever

3. Grass tetany

4. Hepatic lipidosis – bile acids in blood

獸醫生理學 第二講 溫度調節(temperature regulation)

(參考：獸醫解剖生理學(中) pp.102 -103)

一。Animals and Temperature Regulation

1. Based on the relationships of body temperature-environment temperature

(1) warm blooded (homeothermic or endothermic) animals

: a constant internal thermal milieu

Dormancy (important term)

a. **Sleep** : It's associated with a drop in both body temperature and hypothalamic temperature sensitivity.

b. **Torpor** : The closer the body temperature is to the air temperature, the less heat is lost to the environment.

c. **Hibernation** (a period of deep torpor or winter dormancy) : During hibernation, the hypothalamic thermostat is reset to as low as 20°C or more below normal.

d. **Winter sleep** : Without a substantial drop in body temperature

e. **Estivation** (in response to high ambient temperature or danger of desiccation) :
The state is similar physiological to hibernation, but differ in seasonal timing.

(2) cold blooded (poikiothermic or ectothermic) animals

: controlled by outside sources of heat and cold (behavioural action → regulatory capability)

2. Physical mechanism of warm blooded animals (macroview)

(1) **stored heat** : $\Delta Q = C$ (specific heat) x M (mass) x ΔT (temperature change)

(2) **complicated interface** : skin and its circulation → 'insulator'

(3) **heat transfer** (→ ambient air) :

2. Physical mechanism of warm blooded animals (continue)

(3) **heat transfer** (→ ambient air) :

- a. The **rate** of heat transfer into/out of an animal depends on three factors :
surface area / temperature difference ($T_a - T_b$) / weight-specific heat conductance
- b. Heat transfer between the body and the environment occurs by the **methods(types)** of :
 - Conduction – between two media in close contact
 - Convection – heat transfer to moving air or water
 - Radiation – the difference in temperature between two objects
 - Evaporation – depends on the relative humidity

3. Factors of physiological controls (microview)

(1) **compartments** : brain, skin, body core (male scrotum)

(2) **skin blood-flow** :

subpapillary venous plexuses/arteriovenous anastomoses/sympathetic chain

(3) **counter-current (heat) exchange**

- a. warm arterial blood(core) \longleftrightarrow cool venous blood(extremities)
- b. thermal gradient (extremities \longleftrightarrow environment)

(4) **arterial retes** (carotid rete)

(5) **hormones** (response to thermal stress) :

- a. **ACTH** → **cortisol** : acclimation response
- b. **TSH** → **thyroxin** : acclimatization response
- d. **ADH**

4. Others

- (1)**sweating** : apocrine gland(sheep)
- (2)**panting** : open-mouth mechanism(dog)
- (3)**salivation** (panting) : (tongue)exposed wet surface area
- (4)**shivering** : muscle hypertonia(hyperactivity)
- (5)**piloerection** (horripilation) : arrectores pilorum
- (6)**behaviour mechanism** : heat exchange

二 • Determinants of body heat and temperature

1.Heat balance (thermal equilibrium)

(1)The **rate of change of body heat** depends on :

- a. the rate of heat production (metabolic means)
- b. the rate of heat gain (environment)
- c. the rate of heat loss (environment)

Body Heat =heat produced+heat gained-heat lost= heat produced+heat transfer

(2)The(**clinical control**)**processes** that influence the rate of body heat production are :

- a. **autonomic change(mechanism)** : increased respiration, shivering
- b. **behavioural change(mechanism)** : food intake, lethargia
- c. **endocrine change(mechanism)** : thyroid hormone, epinephrine
- d. **somatic change(mechanism)** : vasodilatation / vasoconstriction

c. + d. = **adaptive mechanism**

三 • Clinical Review

1.Hypothermia

(1) surgery

prolonged arrest of circulation→.blood—extracorporeal heat exchanger

(2) exposed to cold environment

2.Hyperthermia

(1) trauma / infection

pyrogen→(hypothalamus)set point increase→intense heat loss

(2) malignant hyperpyrexia

anesthesia→**muscle hypertonia**

(3) exposed to hot environment

一。Fluid Compartments

(一)Distribution

- 1.intracellular fluid (ICF) (70%)
- 2.blood-plasma (7-8%)
- 3.interstitial fluid (ISF) / lymph (20%)
- 4.transcellular fluid* (2-3%)

*A special form of ECF which is secreted by specialized cells other than the **capillary endothelium**. — intraocular, cerebrospinal, synovial, peritoneal, pleural fluids.

(二)Compositions

Typical conc. Of major ions (mEq / L) in three fluid compartments

	Ca	Cl	HCO ₃ ⁻	K	Mg	Na	HPO ₄ ⁼	Protein
Plasma	5	105	27	5	3	155	2	17
ECF	3	110	29	4.5	2	150	1	—
ICF	>0.2	5	10	150	28	8	100	65

二。Gibbs-Donnan Equilibrium (unstable equilibrium)

compartment 1 (5 mole)	compartment 2 (10mole)
Na ⁺	Na ⁺
P ⁻	Cl ⁻

1.According to Gibbs-Donnan Rule :

$$[\text{Na}^+]_1 \times [\text{Cl}^-]_1 = [\text{Na}^+]_2 \times [\text{Cl}^-]_2 ,$$

$$\text{if : } [\text{Cl}^-]_1 = X, \text{ then } [\text{Na}^+]_1 = C_1 + X$$

$$\text{and : } (C_1 + X) X = (C_2 - X) (C_2 - X), X = 10 \times 10 / [5 + (2 \times 10)] = 4$$

$$\text{so : } [\text{Na}^+]_1 = 9, [\text{Cl}^-]_1 = 4, [\text{Na}^+]_2 = [\text{Cl}^-]_2 = 6.$$

2.follow the *Electroneutrality* ;

3.follow the *Concentration Gradient — Osmotic Pressure Gradient* ;

4.*Stability* can be achieved by :

rigid walls /hydrostatic (pressure) forces /active transport mechanism

三。The movements of body fluid and equilibrium

(參考：獸醫解剖生理學(中) pp.117-119)

(一)The forces producing the movements of body fluid

(二)Exchange between ECF and ICF

(三)Output of water and electrolytes

四。Fluid balance (plasma / tissue)

1. hydrostatic pressure : blood pressure(BP) / fluid pressure(FP)

2. colloid osmotic pressure (COP)

3. arterial end / venous end

4. filtration pressure (a) / reabsorption pressure(b)

		(b)
e.g. (dog)	ARTERIAL END	VENOUS END
COP (Blood)	25 mm Hg	25 mm Hg
BP	32 mm Hg	12 mm Hg
COP (ISF)	10 mm Hg	10 mm Hg
FP	5 mm Hg	5 mm Hg
	12 mmHg (a)	8 mmHg↓



五。Regulation of acid-base balance

1. Buffer*

*A substance which has the ability to **bind or release H^+** in solution, thus maintaining the pH of a solution relatively constant **despite the addition** of considerable quantities **of acid or base**.

In the RBC : Hb or HbO₂ ~~HHb~~ or HHbO₂

In the plasma : protein or HCO₃⁻ ~~H₂protein~~ or HHCO₃⁻

2. The effects of kidney and lung on pH regulation

(參考：獸醫解剖生理學(中) p.121)

六。Clinical Review

1. 臨床脫水病例治療之考量

(1)由脫水之程度→減輕之體重→失去之水分：估算下痢後之體液量

(2)由正常總Na量與下痢後之總Na量：估算損失之Na量

(3)由下痢前後之Na差值去估算ECF量與ICF量：最後估算兩者損失之量

治療設計 (mEq/L)

	Na	K ⁺	Ca ⁺⁺	Cl ⁻	HCO ₃ ⁻	
<i>lactated Ringer's soln.</i>	130	4	3	109	28	
<i>multisol-Ringer's soln.</i>	140	5	0	98	50	
<i>0.9% saline</i>	154	0	0	154	0	
<i>plasma-Lyte A</i>	140	5	0	96	50	

2. Edema (appendix)

11

(參考：獸醫解剖生理學(中) pp.23-43)

一。內容：

(一)採食(prehension)

1.目的(purpose)：energy produced

2.選擇條件(selective grazing conditions)：

period(safety)

site (leaf / stem ; green / dry ; special content)

sense (sight, touch, **taste**, smell) : **signals**

signals→receptor sites→brain

chemical

vibration

molecular concentration(specific chemical form↔chemical 'noise')

relative intensity

the number of **molecules received**

the number of **appropriate receptors**：

total number of receptors

the ratio of bitter to sweet taste receptors

3.影響因素(influencing factors)：

macro-view

micro-view

regulatory mechanisms

4.使用方法(或工具)(methods / tools)

food intake

mastication

lubrication(saliva)

deglutition

(二)唾腺特論(special topic of salivary gland)

1.structures

2.functions

3.regulations

4.related important research

(1) **nerve growth factor**

a neurotrophic peptide necessary for the maintenance of sympathetic & embryonic sensory neurons.

Biological Effects :

a.neurotrophic activity

b.regulates survival, differentiation, and functional properties of neutrophils

c.chemotactic activity for neutrophils

d.**truck transportation stress** induce NGF release into the peripheral blood and lead to fever and neutrophilia

(2) epidermal growth factor

a.EGF are intensely in the stroma of the bovine endometrium (while the IGF-1(insulin-like growth factor-1) are intensely in the luminal and glandular epithelium).

b.EGF induces a decrease in the adverse effects of PDT(photodynamic therapy) to glioblastoma and PDT increases expression of EGF receptors.

二。Clinical Review

1.sublingual & mandibular gland : ranula(cyst)

2.parotid gland : superficial injury/Vit.A deficiency/human mumps virus↔cat, dog

3.sialolithiasis

4.betelnut

一。生理活性 (physiological activity)

(一)運動(motility)

- 1.ruminoreticular activity ; reticulo-rumen motility
- 2.rumination
- 3.eructation
- 4.esophageal groove closure reflex
- 5.omasal movement
- 6.abomasal secretion

(二)微環境(micro-environment)

- 1.impulsive forces
- 2.products
- 3.significances

(三)The microbial ecosystem of fermentative digestion :

- 1.The microbes responsible for fermentative digestion include :
bacteria, fungus and protozoa
- 2.Plant cell walls are important substrates for fermentative digestion and important nutrient sources for many species :
plant cell walls vs. connective tissue of animal
cellulose vs. collagen
hemicellulose / pectin / lignin vs. hyaluronic acid / chondroitin sulfate
(cement the cellulose) (cement the connective tissue)

(四) Reticulum motility and the maintenance of the rumen environment

Several requirements that must be met by the host for proper fermentation to occur :

- 1.substrate
- 2.temperature (37°C)
- 3.ionic strength (osmolality, 300 mosm)
- 4.negative oxidation – reduction potential (-250 to -450 mV)
- 5.indigestible waste (solid material) must be removed
- 6.rate of removal of microbes vs. the regeneration times of the favorable microbes
- 7.acid products of anaerobic fermentation (VFA) must be buffered or removed 15

Gravity and reticulorumen motility combine to create the *selective flow* of particulate matter out of the rumen.

Rumen ingesta are **stratified** and segregated :

(1) created by *Gravity* :

(dorsal rumen) **gas cap** / **solid zone** (fermenting forage) / **slurry zone** / **liquid zone**

(2) created by the *Motility* :

ejection zone / **zone of potential escape** (constitute the dorsal & ventral areas of the reticulum & cranial sac)

Fuctional specific gravity (FSG)determines the rate at which particulate matter (solid) moves through the zones of the reticulorumem.

initial : the FSG of bolus $< 1 \rightarrow$ floats in the **ejection zone** ;
until a reticulum contraction \rightarrow into the **solid zone**.

then : **bacteria** adhered to the *forage particle* + *fermentation*

a. particle size reduced (air escapes) \rightarrow FSG increased

b. particle sink & separate into a **slurry zone** (dense)

c. **cranial pillar** / **cranial sac** / **zone of potential escape**

final : during contraction of the **cranial sac** \rightarrow **reticulum** ;
exit the rumen through the reticulo-omasal orifice.

Rumination (cud chewing) has an important effect on **particle size reduction** and the movement of solid material through the rumen.

Regurgitated material for remasticatin comes from the dorsal portion of the reticulum
(has particle size & FSG that are characteristic of the **slurry zone** \rightarrow not the coarsest material in the rumen)

二。Clinical Review

1.chemical ruminitis

2.ruminal indigestion complex

3.laminitis

16

獸醫生理學 第六講 單胃生理學(Simple Stomach)

(參考：獸醫解剖生理學(中) pp.43-57)

(一)目的：七情六慾

(二)構造

1.解剖學（區域性）

賁門—胃底部—胃體部—幽門

2.生理學（分泌性）

(1)腺體：賁門腺—胃底腺—幽門腺

(2)細胞：粘液頸細胞—表面粘液細胞—嗜銀細胞—壁細胞—主細胞

(三)消化液

1.酶類：如胃蛋白酶、凝乳酶、解脂酶

2.非酶類：如胃酸、粘液、胃泌素

(四)胃酸與蛋白酶之分泌管制

1.乙醯膽鹼

2.腸阻胃泌素

3.腎上腺素/正腎上腺素

4.糖質皮質類固醇

5.迷走神經

(五) Clinical Review：胃炎(gastritis)、消化性潰瘍(peptic ulcer)

1.mucus

2.tight junction

3.new cell

4.bile salt(detergent action)

5.inflammation→mast cell→acid secretion→acute gastritis→gastric ulcer

獸醫生理學 第七講 下消化道生理學(Lower Alimentary Tract)

(參考：獸醫解剖生理學(中) pp.83-98)

(一)小腸

1.功用：接受來自胃部之食糜(chyme)

2.重要構造

(1)粘膜層

(2)絨毛：平滑肌－多種功能性細胞－微絨毛

(二)十二指腸腺

1.功用：保護粘膜

2.分泌成分：粘液蛋白(mucoprotein)、腸阻胃泌素(enterogastrone)

(三)肝臟－膽汁輸送系統

1.庫弗氏細胞

2.肝實質細胞

3.杯狀細胞

4.嗜銀細胞

(四)胰臟

1.粘液

2.重碳酸鹽

3.消化酶

(五)大腸

1.草食獸/雜食獸：發酵作用(盲腸、結腸)

2.肉食獸：吸收電解質、維生素、脂肪酸、氨基酸

3.共同性：分泌粘液、再吸收水分

(六)相關功能

1.免疫：lymphocyte-plasma cell-Peyer's patch(IgM)-IgA

2.發酵作用：乳酸桿菌－鏈球菌－大腸桿菌－類細菌－酵母菌

(七)Clinical Review：下痢(Diarrhea)