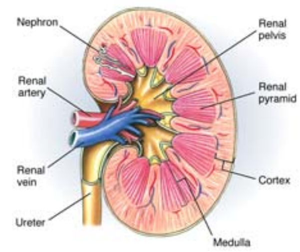
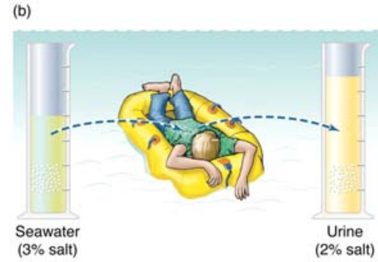
Lecture 30+31
02+04 April 2008

Vertebrate Physiology
ECOL 437 (MCB/VetSci 437)
Univ. of Arizona, spring 2008

Kevin Bonine & Kevin Oh



1. Osmoregulation (Ch 25&26)



http://eebweb.arizona.edu/eeb_course_websites.htm

1

Housekeeping, 02 April 2008

Upcoming Readings
Wed 02 Apr: Ch 25&26
LAB 02 Apr: Lillywhite 1988, Zapol 1987
Fri 04 Apr: Ch 25&26
Mon 07 Apr: Ch 27
Wed 09 Apr: Ch 27&28
LAB Wed 09 Apr : no reading
Fri 11 Apr: Exam 3

Lab discussion leaders: 23 April
1pm – none
3pm – Nina

2

PHYSIOLOGY

Lise Bankir, PH.D.
Director of Research, 1st Class
INSERM Unit 872
University Pierre and Marie Curie
Paris, France

"Urea handling by the mammalian kidney. Lessons from knockout mice."

Friday, April 11, 2008 11:00 a.m.

AHSC Room 5403

Refreshments will be served

Also available on-line at:
http://www.physiology.arizona.edu/seminars

Host: Bill Dantzler, 626-7646 dantzler@email.arizona.edu

3

Vertebrate

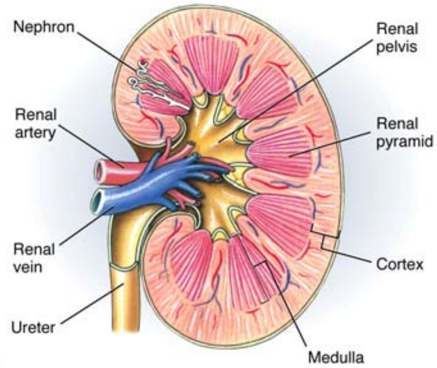
Osmoregulation

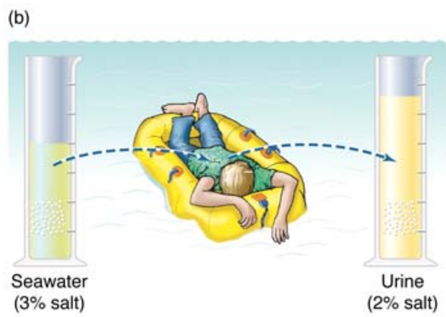
4

Osmoregulation

-Ionic and
Osmotic Balance

-Kidney Function



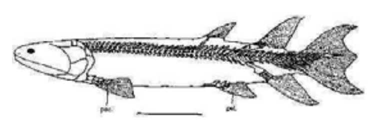


5

Osmoregulation

-life arose in salty sea

-extracellular fluids ~ similar



-dist'n limited by temperature and osmotic pressure
(dehydration, ionic composition)

-terrestrial organisms (and their descendents) regulate internal environment (homeostasis)

-salt and water regulation (waste excretion)

-kidneys, salt glands, gills

6

Obligatory Osmotic Exchanges

1-Gradients

-Frog in freshwater

-Fish in ocean

2-Surface-to-Volume Ratio

-Small animals dehydrate or hydrate more rapidly

-Skin, and Respiratory surface
(higher metabolism with higher per/gram
respiratory surface)

3-Integument Permeability

-Transcellular or Paracellular

-Aquaporins = water channel proteins

-Frogs vs. Lizards, Pelvic Patch etc.

7

Obligatory Osmotic Exchanges

4-Feeding, Metabolism, Excretion

-metabolic waste products
ammonia, urea, etc.

-metabolic water (desert!)

-ingestion of salts

-kidneys, salt glands, gills (more later)

5-Respiration

-internalize respiratory surface

-temporal countercurrent system
(dry and cool IN, becomes moist and warm; recover)
(countercurrent blood flow also)

-temperature regulation vs. water conservation

-ectotherm vs. endotherm (in deserts)

8

Osmoregulation

-Water Breathing

1. Fresh

Ambystoma tigrinum

Blood osmolarity 200-300 mosm/L

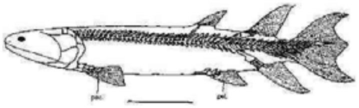
Water ~ 50 mosm/L

- hyperosmotic animals, danger of swelling, losing salts
- get their water across skin
- dilute urine
- active uptake of salts across epithelium
- fish gills, frog skin, etc.

9

Osmoregulation

-Water Breathing



2. Salt (~1,000 mosm/L)

Most marine vertebrates hypo-osmotic
(e.g., teleost or bony fishes)

- danger of losing water, gaining too many salts
- drink saltwater
- excess salts actively secreted (gills, kidneys)
- chloride cells for salt secretion

10

Osmoregulation

Lecture 31, 04 April?

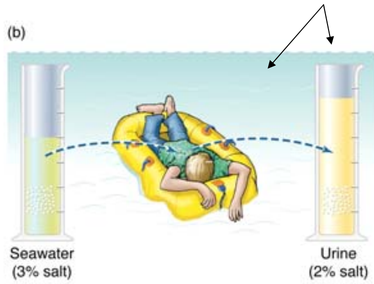
-Air Breathing

Have to lose water to allow gas exchange

- Marine reptiles and marine birds can drink seawater and secrete salts in high [ ]

- SALT GLANDS

- Mammals rely on kidney



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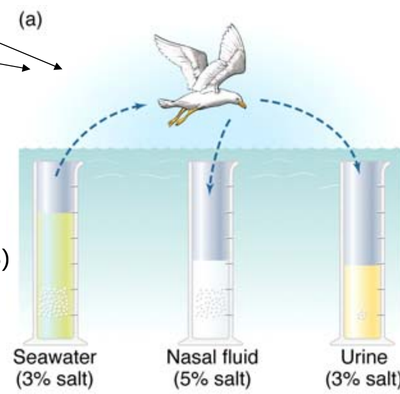


TABLE 25.3 Average gross amount of metabolic water formed in the oxidation of pure foodstuffs The values in this table apply to the oxidation of materials that have been absorbed from a meal and to the oxidation of materials stored in the body. To emphasize this, the materials are called foodstuffs rather than foods. The gross amount of metabolic water formed is, by definition, simply the amount made by the oxidation reactions.

Foodstuff	Grams of H_2O formed per gram of foodstuff
Carbohydrate[a]	0.56
Lipid	1.07
Protein with urea production[b]	0.40
Protein with uric acid production[b]	0.50

Source: After Schmidt-Nielsen 1964.
[a] Starch is assumed for the specific value listed.
[b] Water yield in protein catabolism depends on the nitrogenous end product.

Water Sources:

1 Free

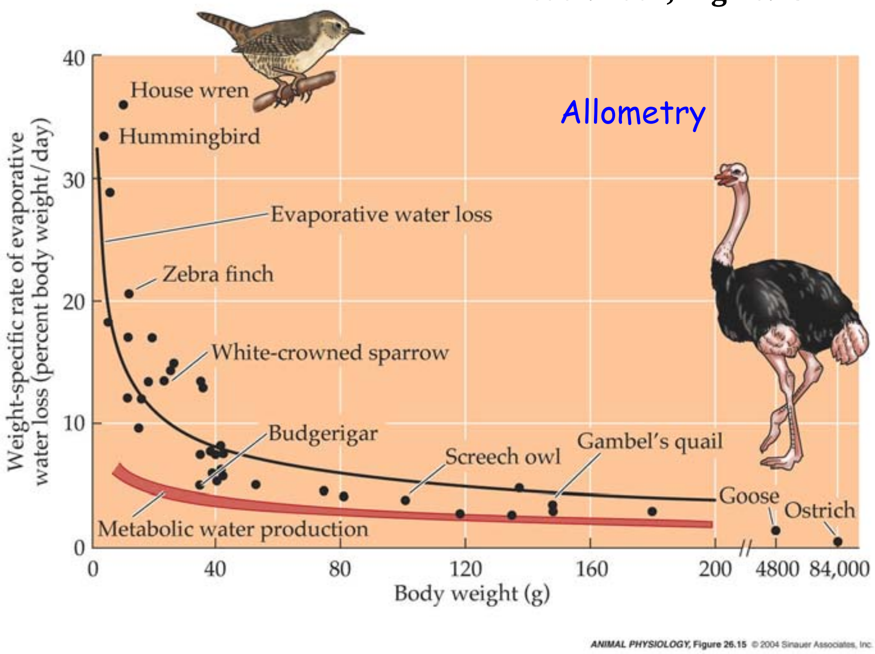
2 Preformed

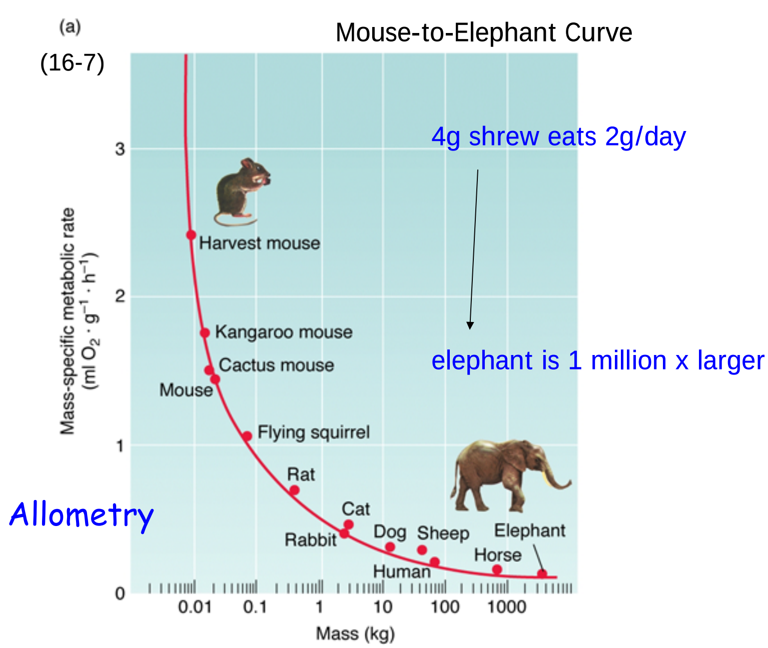
3 Metabolic

$C_6H_{12}O_6 + 6O_2 \leftrightarrow 6CO_2 + 6H_20$

12

Hill et al. 2004, Fig 26.15





14


Camel


Oryx


K-rat


Hopping Mouse

15

K-rat 


Lab rats

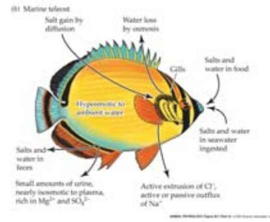
TABLE 25.4 Approximate catabolic gains and losses of water in caged kangaroo rats (*Dipodomys*) and laboratory rats (*Rattus*) when eating air-dried barley and denied drinking water at 25°C and 33% relative humidity The values given are grams of H_2O per gram (dry weight) of barley ingested. Those for the kangaroo rats are from Box 25.1.

Category of water gain or loss	Kangaroo rats	Laboratory rats
Gross metabolic water produced	**0.54 g/g**	**0.54 g/g**
Obligatory water losses		
Respiratory	0.33	0.33
Urinary	0.14	0.24
Fecal	0.00	0.03
Total obligatory water losses	**0.47**	**0.60**
Net gain of metabolic water	**+ 0.07**	**– 0.06**

16

ORGANS THAT CONTRIBUTE TO OSMOREGULATION
IN VERTEBRATES

Group	Osmoregulatory Organs
Fish	**Kidneys Gills Bladder Intestine**
Amphibians	**Kidneys Gills Bladder Skin Intestine**
Reptiles	**Kidneys Salt Glands Intestine**
Birds	**Kidneys Salt Glands Intestines**
Mammals	**Kidneys**

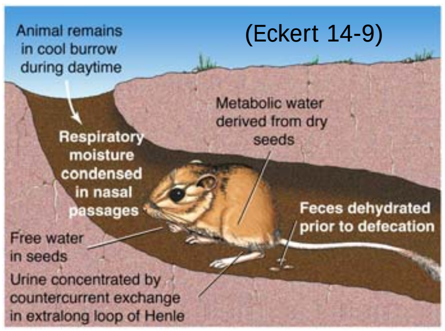


17

Osmoregulation

-<u>Air Breathing Desert Mammals</u>

Behavior and Physiology

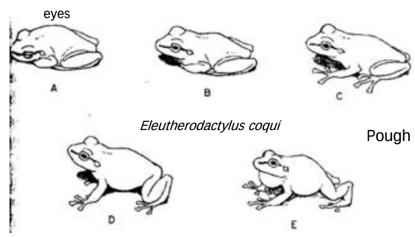


Kangaroo Rat
-Reduce Activity
-Remain in Cool Burrow
  -Humid
  -Water into dry seeds
-Highly concentrated urine
-Very dry feces (rectal absorption)
-Metabolic water

18

Water

Lose water:
- evaporation
- urine
- feces
- salt glands



Pough et al., 2001

Alter behavior and physiology to minimize water loss
Water balance limits activity in time and space

Amphibs lose most water via evaporation
- cutaneous resistance
    1 dried mucus
    2 cocoon
    3 wax

Role of microhabitat

19

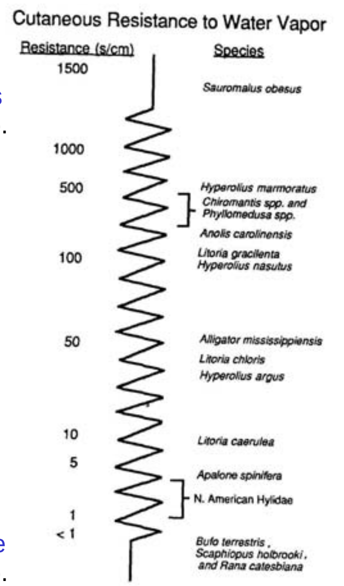
Phyllomedusa

Phyllomedusa sauvagi

Figure 5–4 **Wiping behavior of the tree frog *Phyllomedusa sauvagei*.** *(Courtesy of Rodolfo Ruibal.)* Pough et al., 2001

Water

Less evap.



More evap.

Figure 5–3 **Cutaneous resistance to evaporation for anurans and reptiles.** The scale is logarithmic. *(Source: Buttemer 1990.)*

Pough et al., 2001

Chuckwalla (lizards have more lipids in skin)

Monkey Tree Frog

Anolis lizard

Alligator

Softshell Turtle

Bufo, Spadefoots, *Rana*

(free water surface)

21