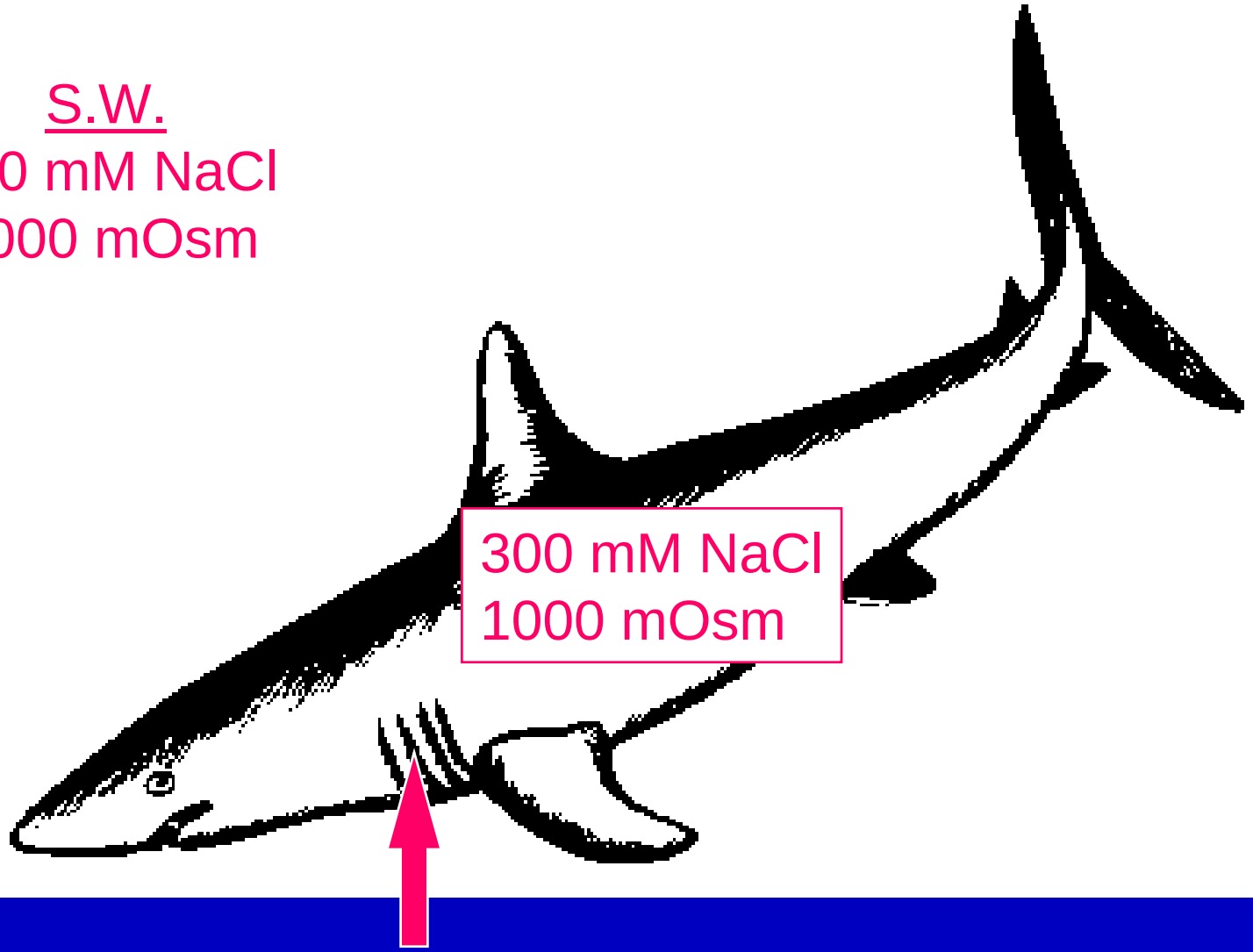
Isosmotic - Hypo-ionic Regulation

Marine elasmobranchs

	mM			
	Na	**Cl**	**TMAO + urea**	**mOsm**
Sea Water	450	500	0	1000
Hagfish Plasma	549	550	0	1150
Teleost Plasma	160	200	0	400
Elasmo. Plasma	290	300	350-400	1000

S.W.
500 mM NaCl
1000 mOsm



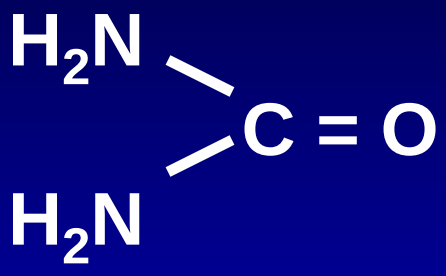
Problem:
Diffusive salt gain

ion(s)

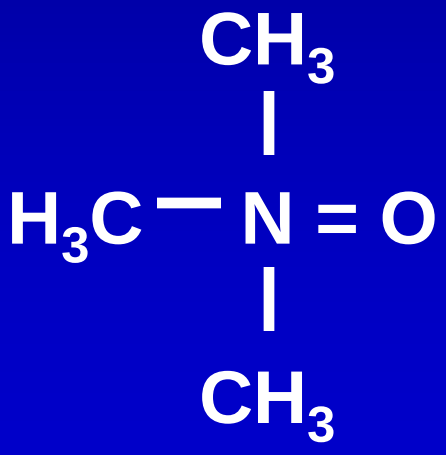
Solution:
Active salt excretion

Elasmobranchs retain nitrogenous compounds as osmotic effectors:

urea



trimethylamine oxide (TMAO)



Urea and TMAO are reabsorbed from the urine.

	mM			
	Na	**Cl**	**TMAO + urea**	**mOsm**
Sea Water	450	500	0	1000
Plasma	250	250	420	1000
Urine	250	250	110	800
Rectal gland fluid	500	500	20	1000

Salt is excreted via rectal gland and chloride cells in the gills.

Terrestrial Animals

Terrestrial environment is relatively water-poor.
Adaptations will involve mechanisms for:

- increasing water gain
- decreasing water loss

Water Loss:

- Excretory
  - urine
  - feces
- Evaporative
  - skin
  - respiration

Water Gain:

- Drinking & eating
  - free H_2O
- Body surface
- Metabolic H_2O
  - $C_6H_{12}O_6$ ===> 6 CO_2 + 6 **H_2O**

Insects and Vertebrates

- Most successful of fully terrestrial animals

  Insects:

  body fluids = 300 mOsm +

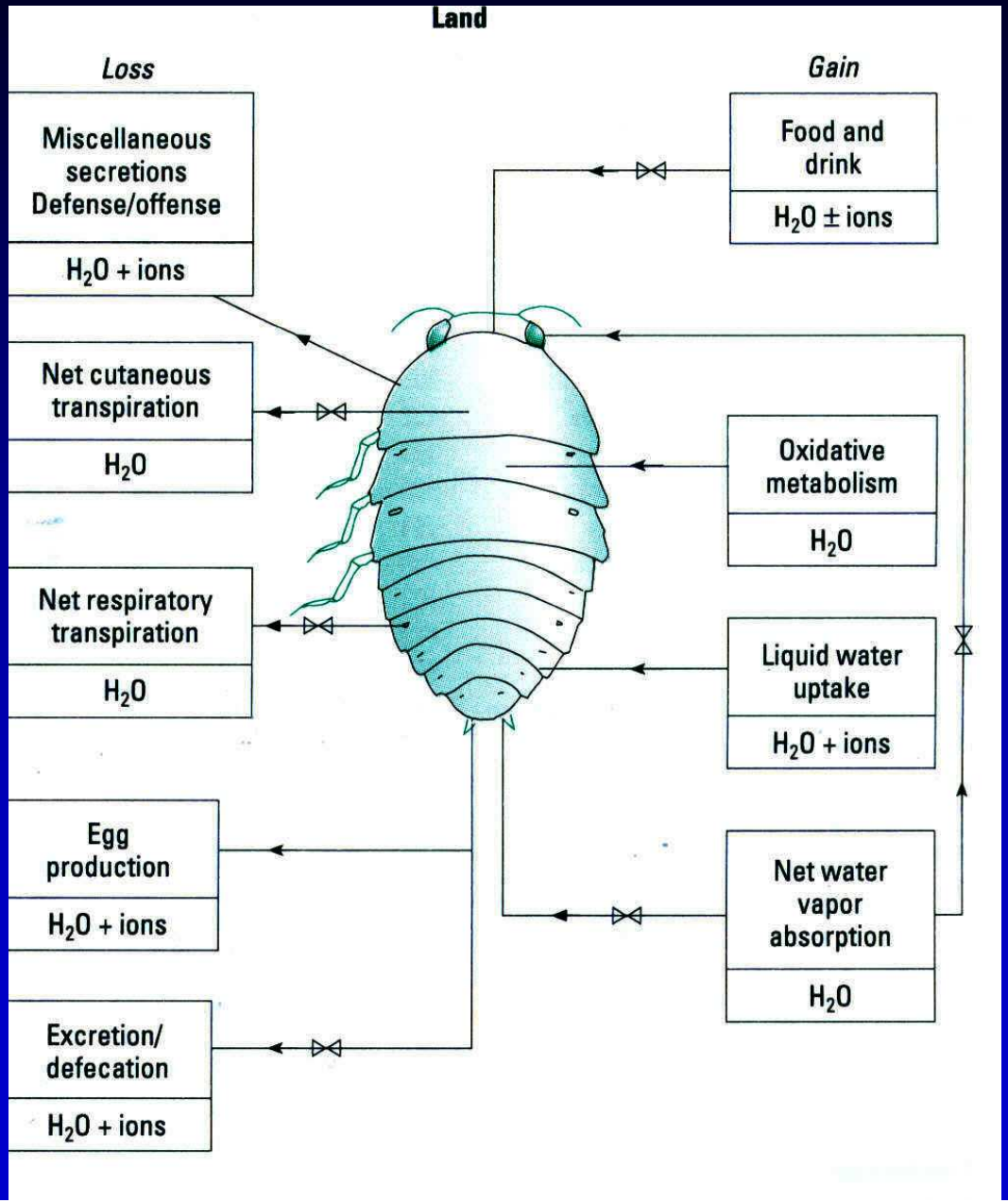
  high amino acid levels; ECF = Na^+, K^+ in some herbivores

  Vertebrates:

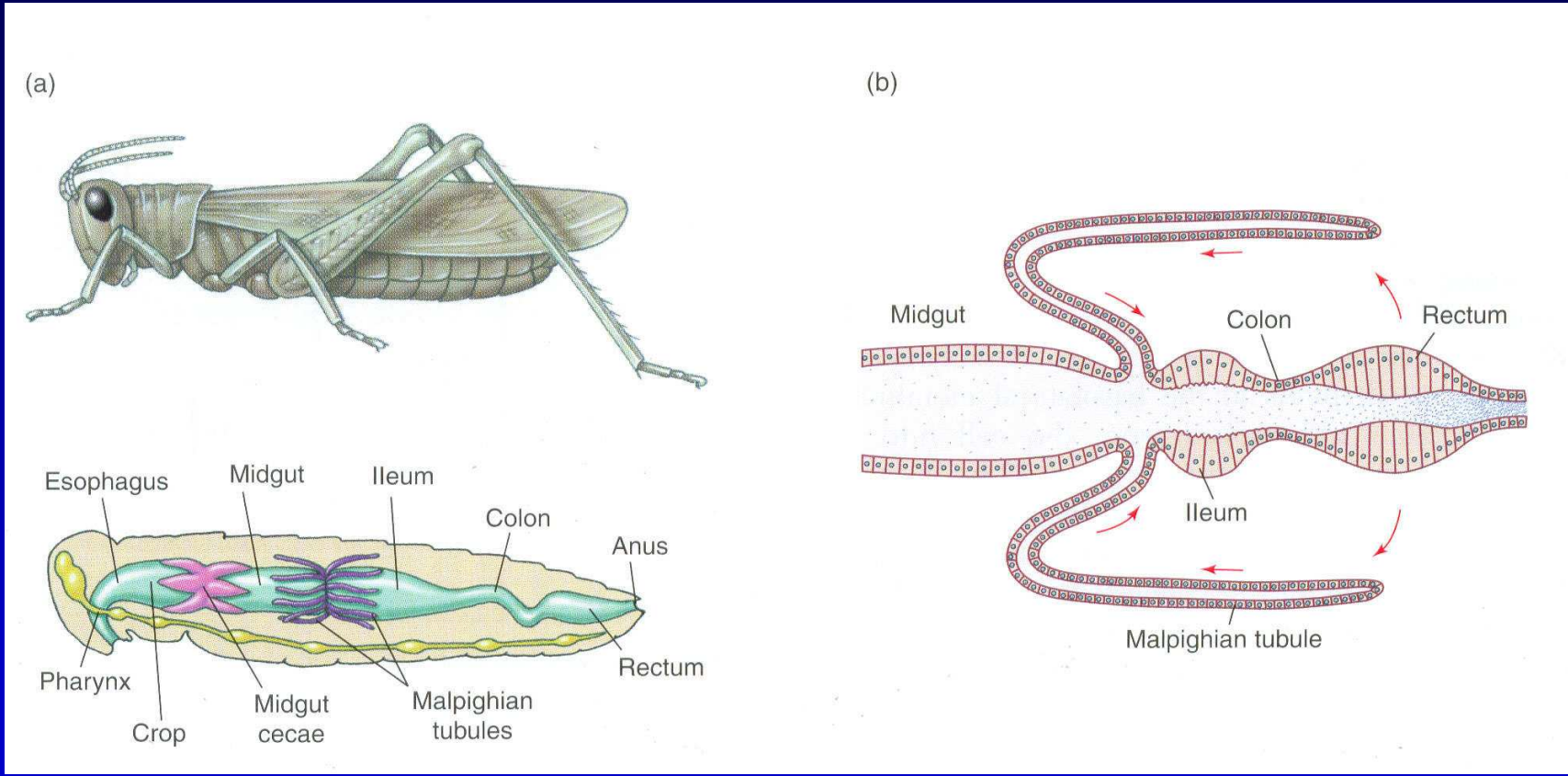
  body fluids = 300 mOsm;

  ECF = NaCl

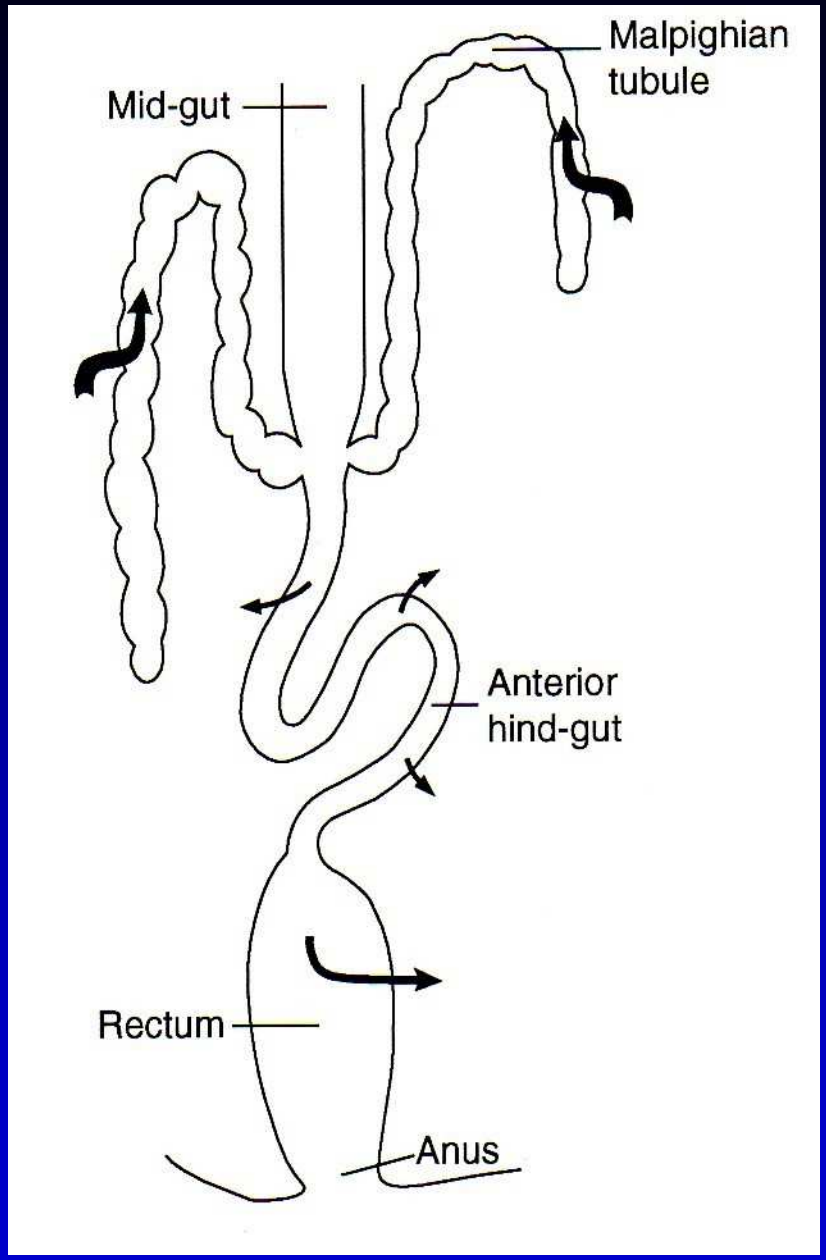
Avenues of Water Gain and Loss in an Insect

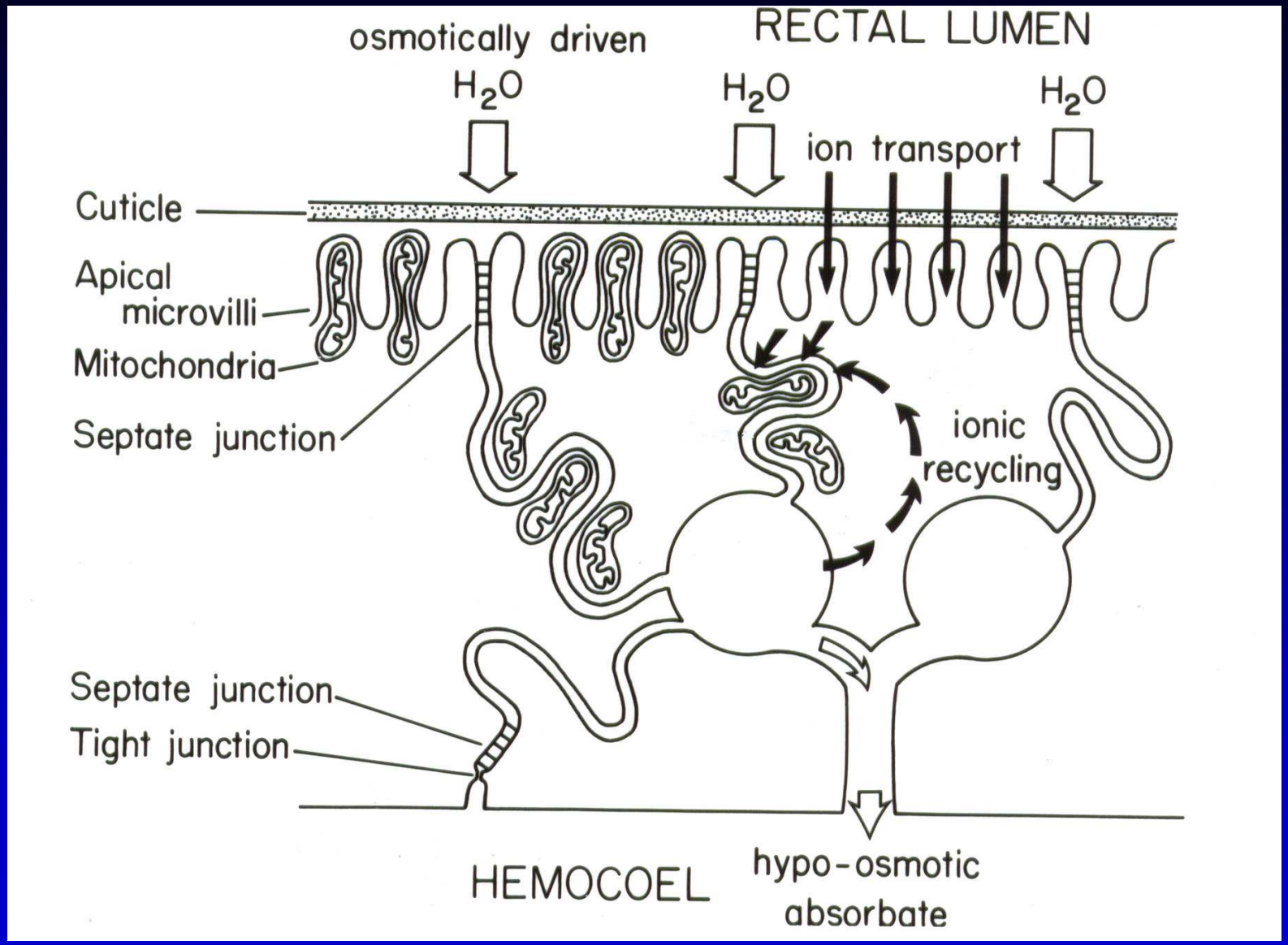


Insect Excretory System



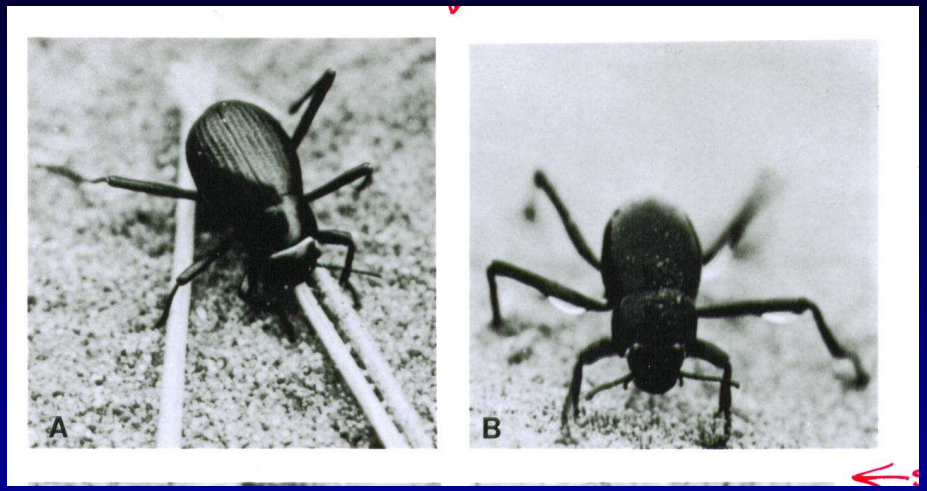
Reduction of excretory water loss in insects is accomplished by the **Malpighian tubules** and the rectum


Malpighian
tubule
Mid-gut
Anterior
hind-gut
Rectum
Anus


osmotically driven
H_2O
RECTAL LUMEN
H_2O
H_2O
ion transport
Cuticle
Apical microvilli
Mitochondria
Septate junction
ionic recycling
Septate junction
Tight junction
HEMOCOEL
hypo-osmotic absorbate

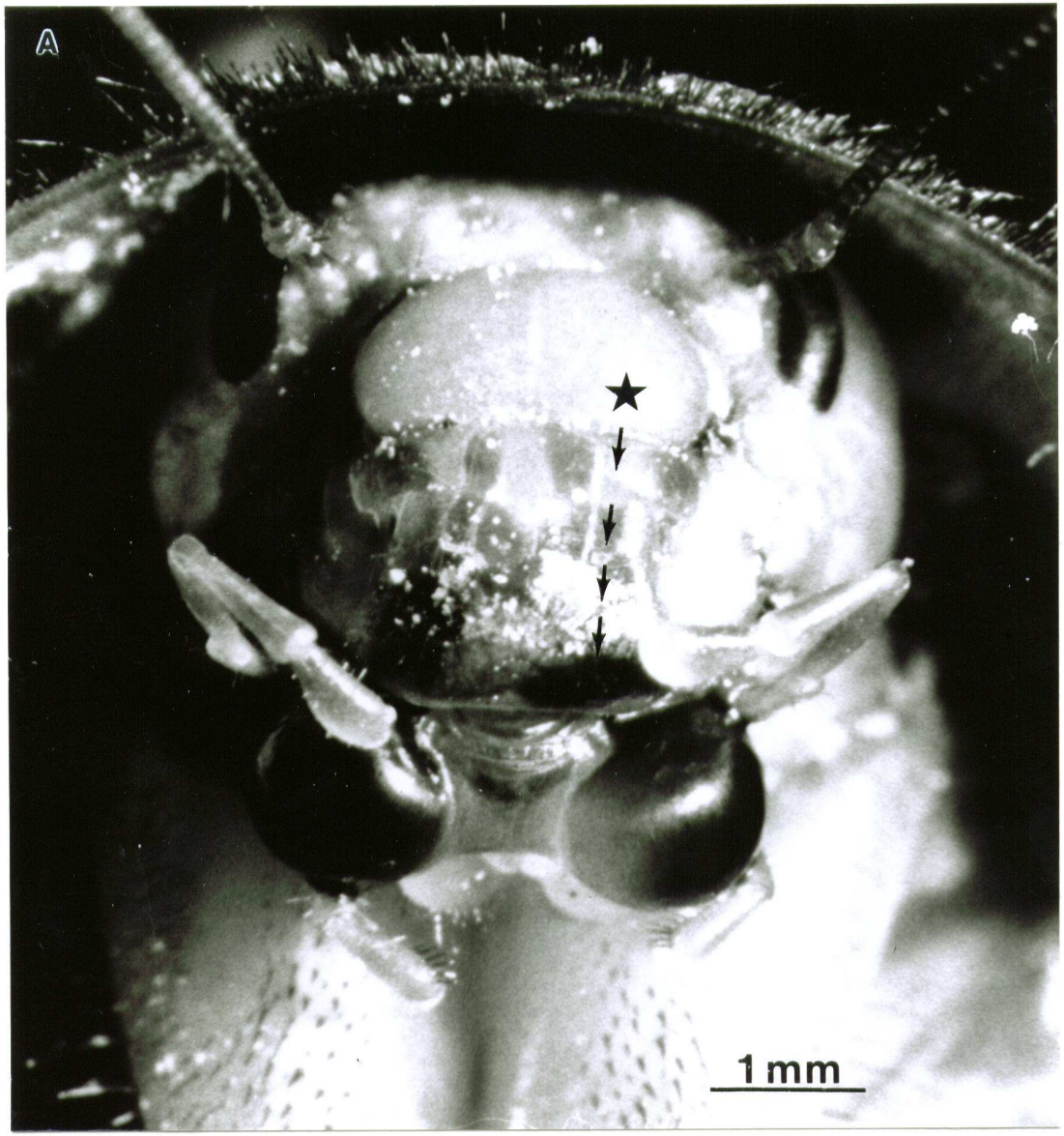
Water Uptake

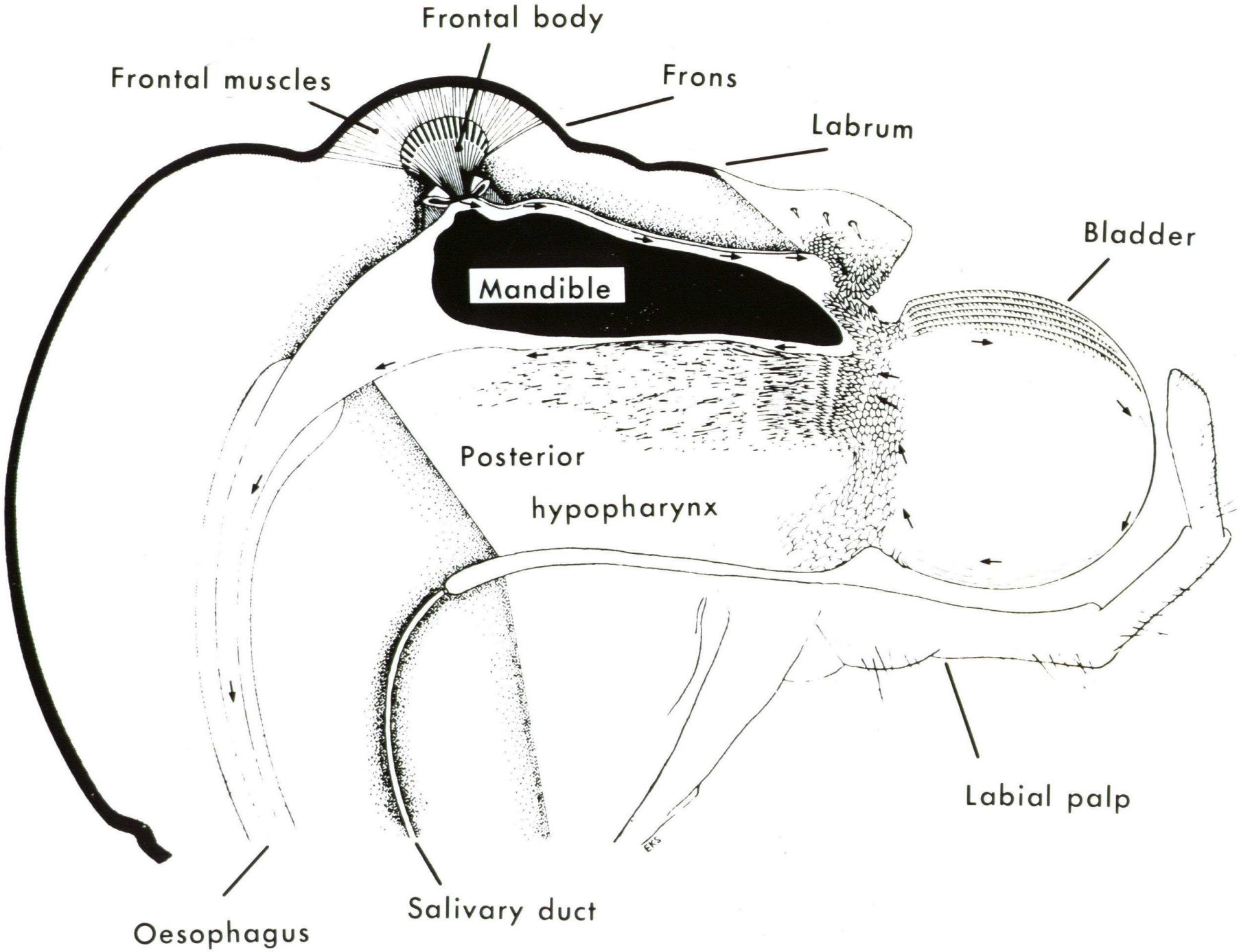
- Preformed water



- Metabolic Water
- Atmospheric Water Vapor

Head of Desert Cockroach




Frontal body
Frontal muscles
Frons
Labrum
Bladder
Mandible
Posterior
hypopharynx
Labial palp
Salivary duct
Oesophagus

Amphibians

Highly dependent on water

Integument permeable to water

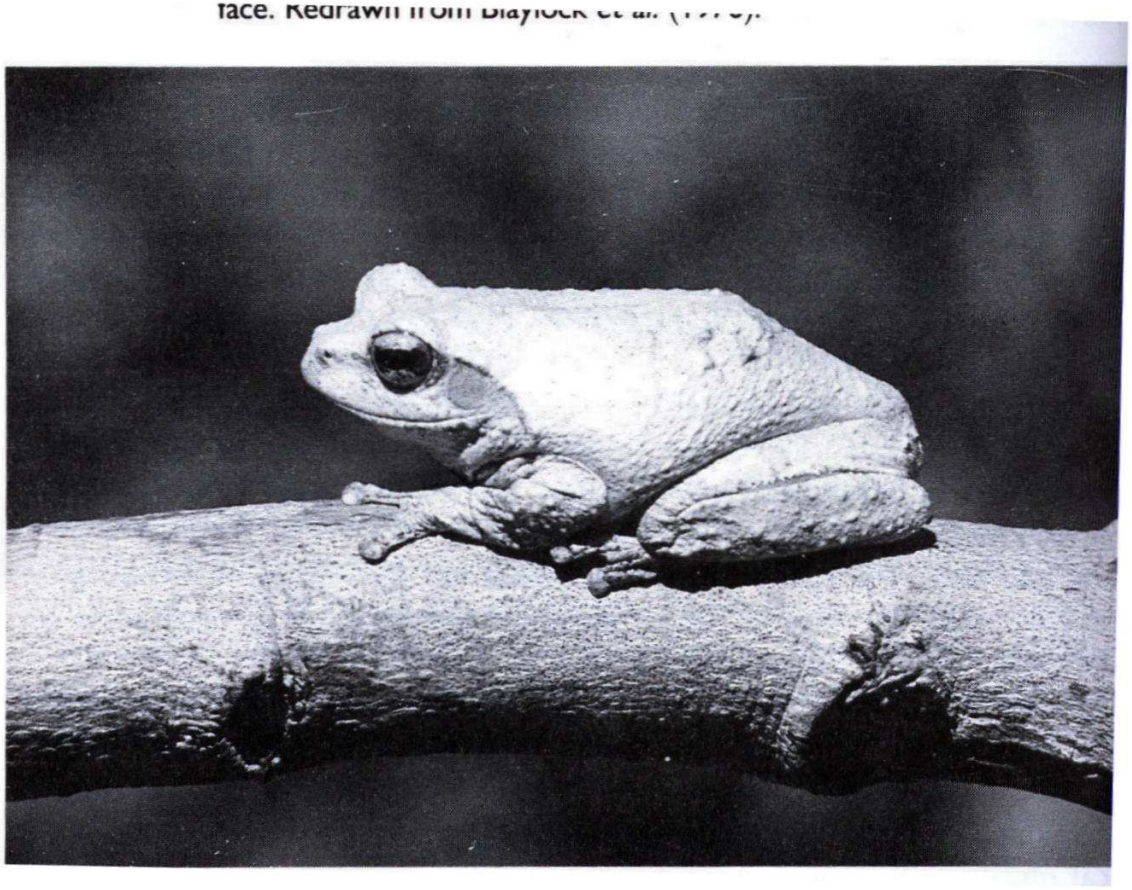
Incapable of producing hypertonic urine

Can regulate their GFR

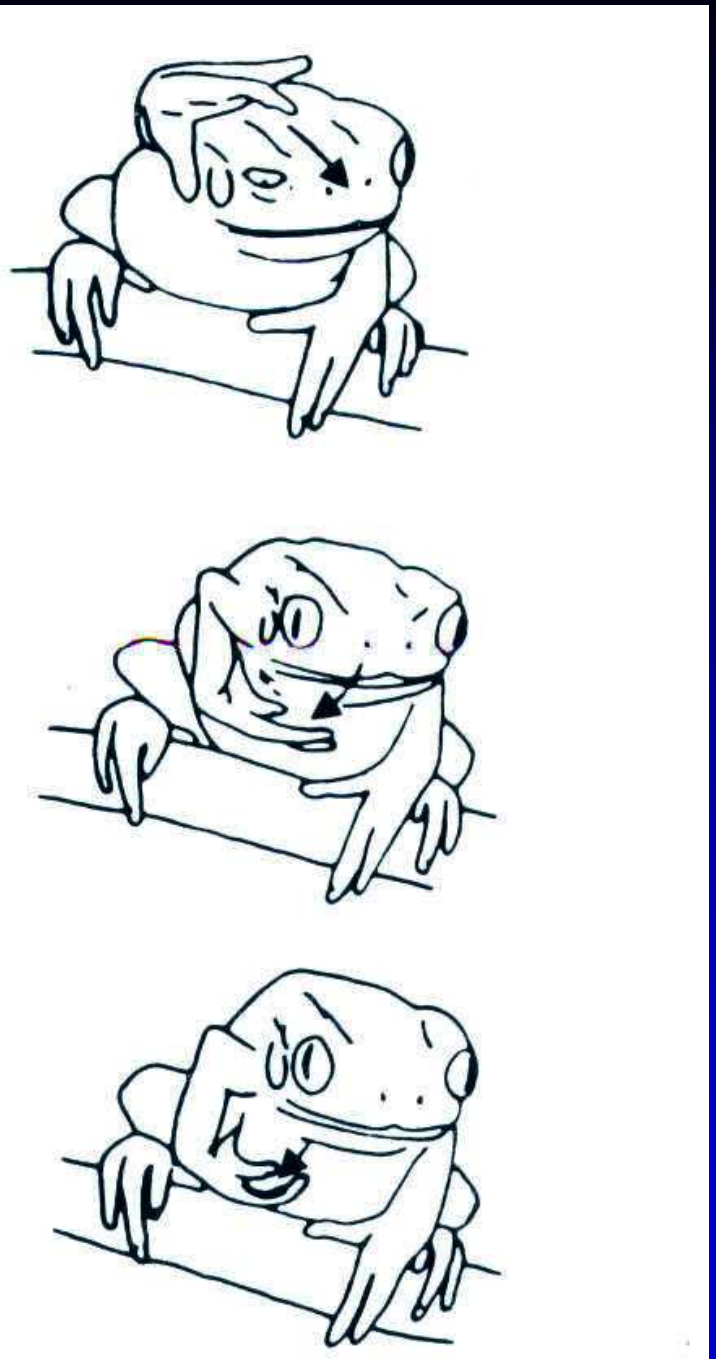
Shift from ammontelism to ureotelism at metamorphsis

African Tree Frog (Chiromantis)

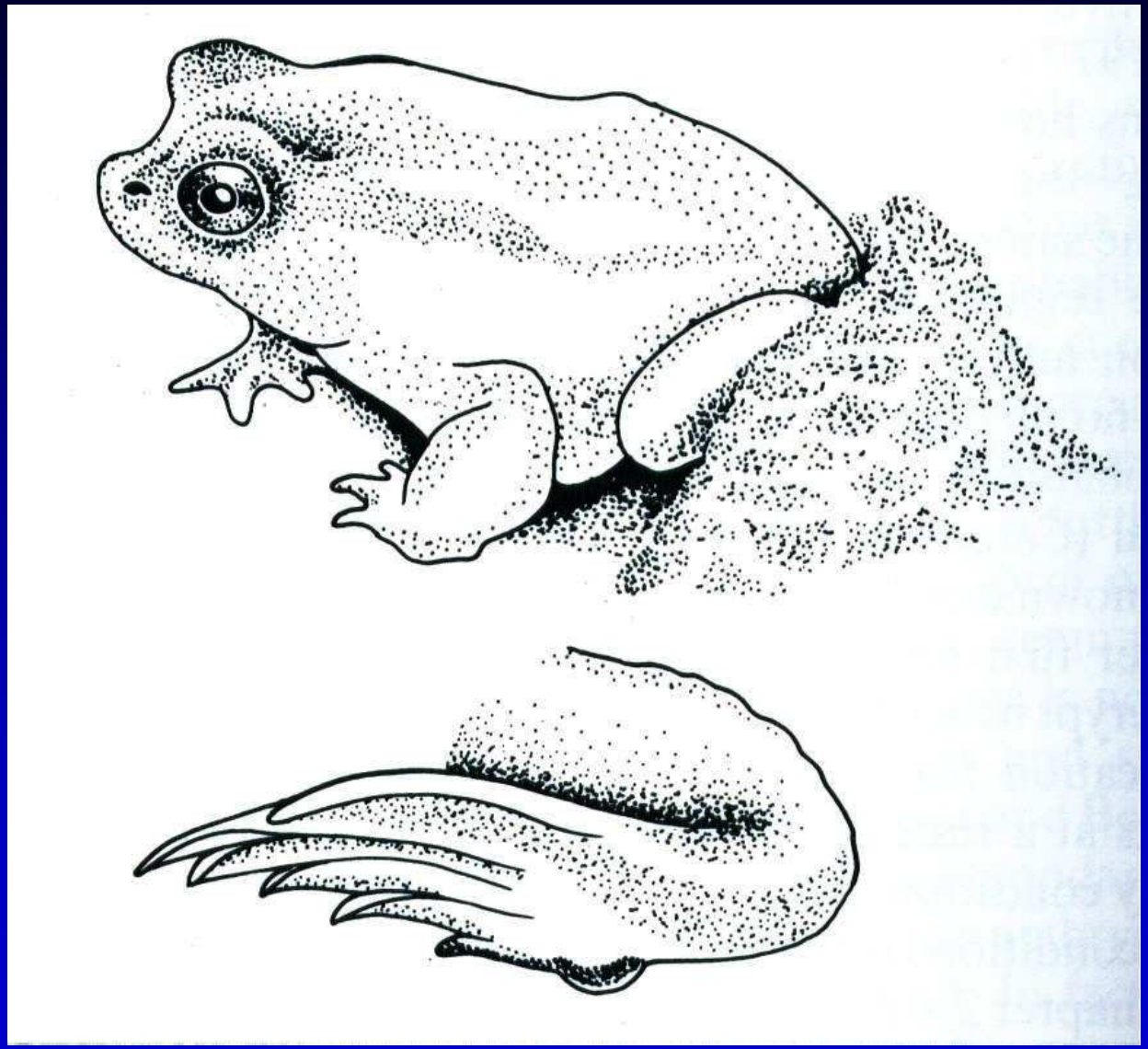
face. Redrawn from Blaylock et al. (1975).



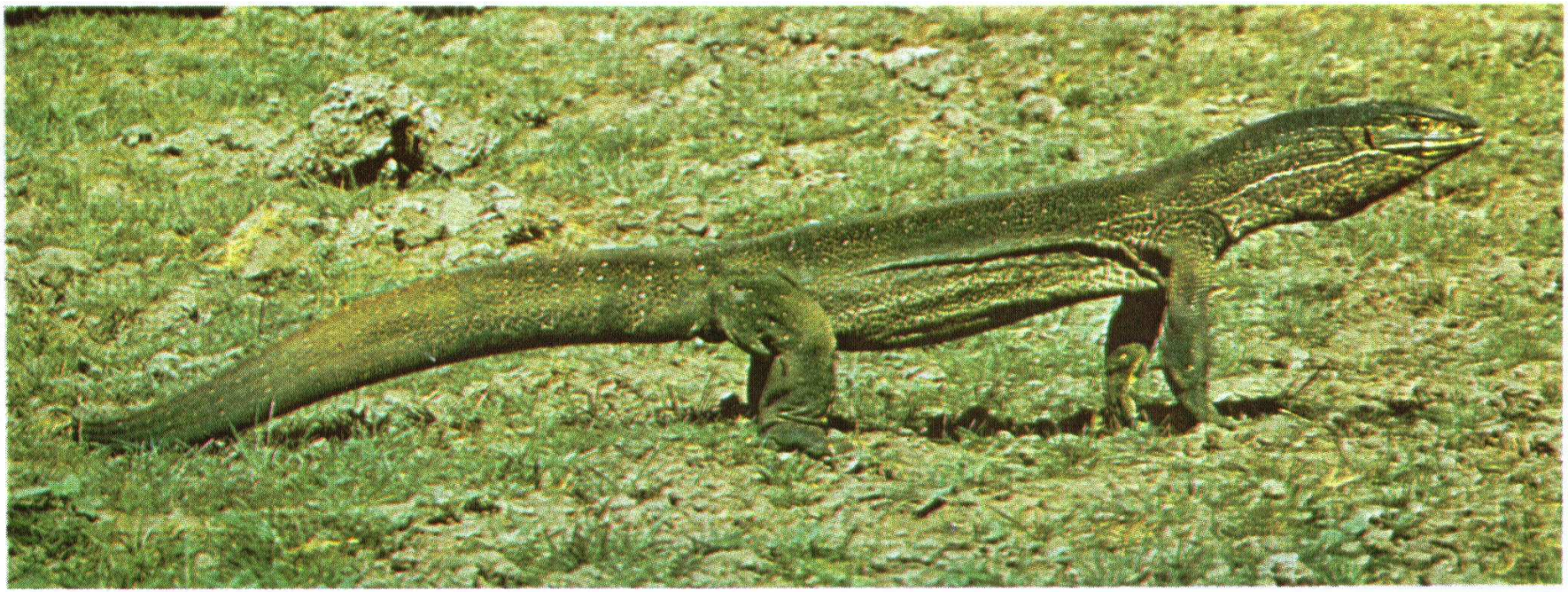
Spreading of lipids by S. American tree frog (*Phylomedusa*)



Spadefoot Toad – Sonoran Desert



Reptiles

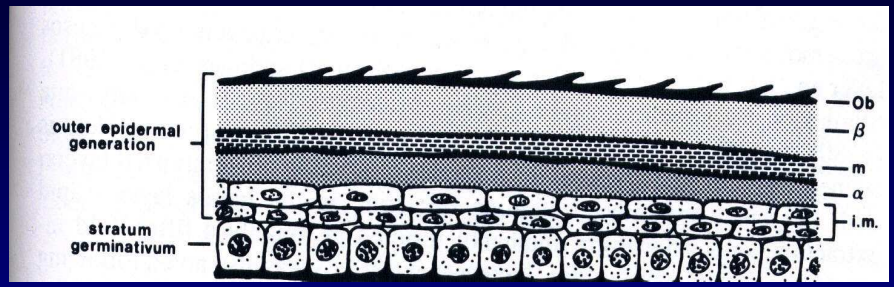


Lace Monitor - Australia

Transition to terrestrial existence complete

Impermeable integument

(scales, keratin, lipid layer)



Cleidoic egg

Uricotelic

Cloacal water reabsorption

Cannot produce hypertonic urine