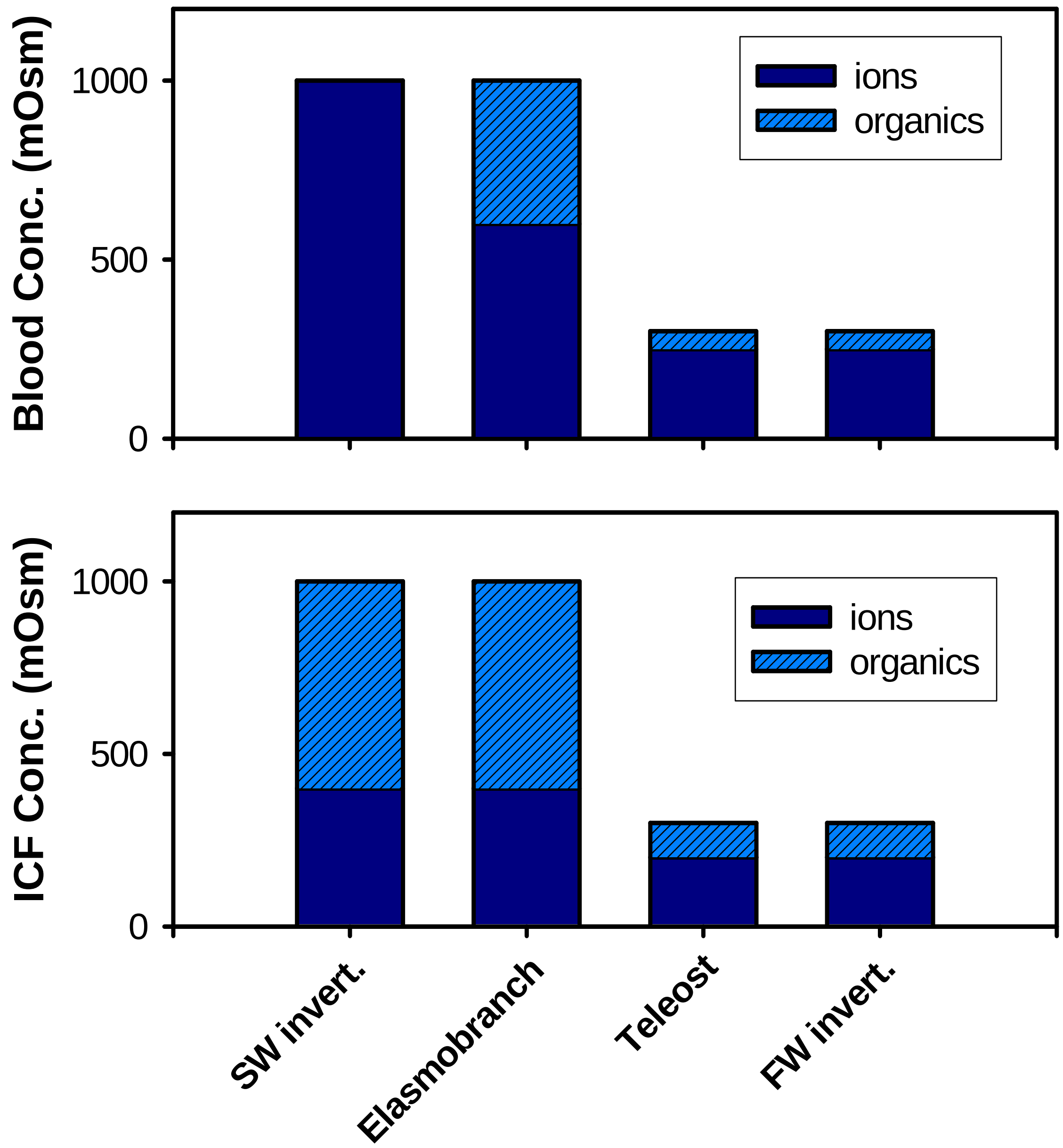
# Osmotic and Ionic Regulation

All animals face osmotic and ionic stresses.

**Stresses depend on environment:**

- Aquatic
  - Marine
  - Freshwater
  - Brackish (estuarine)
- Terrestrial

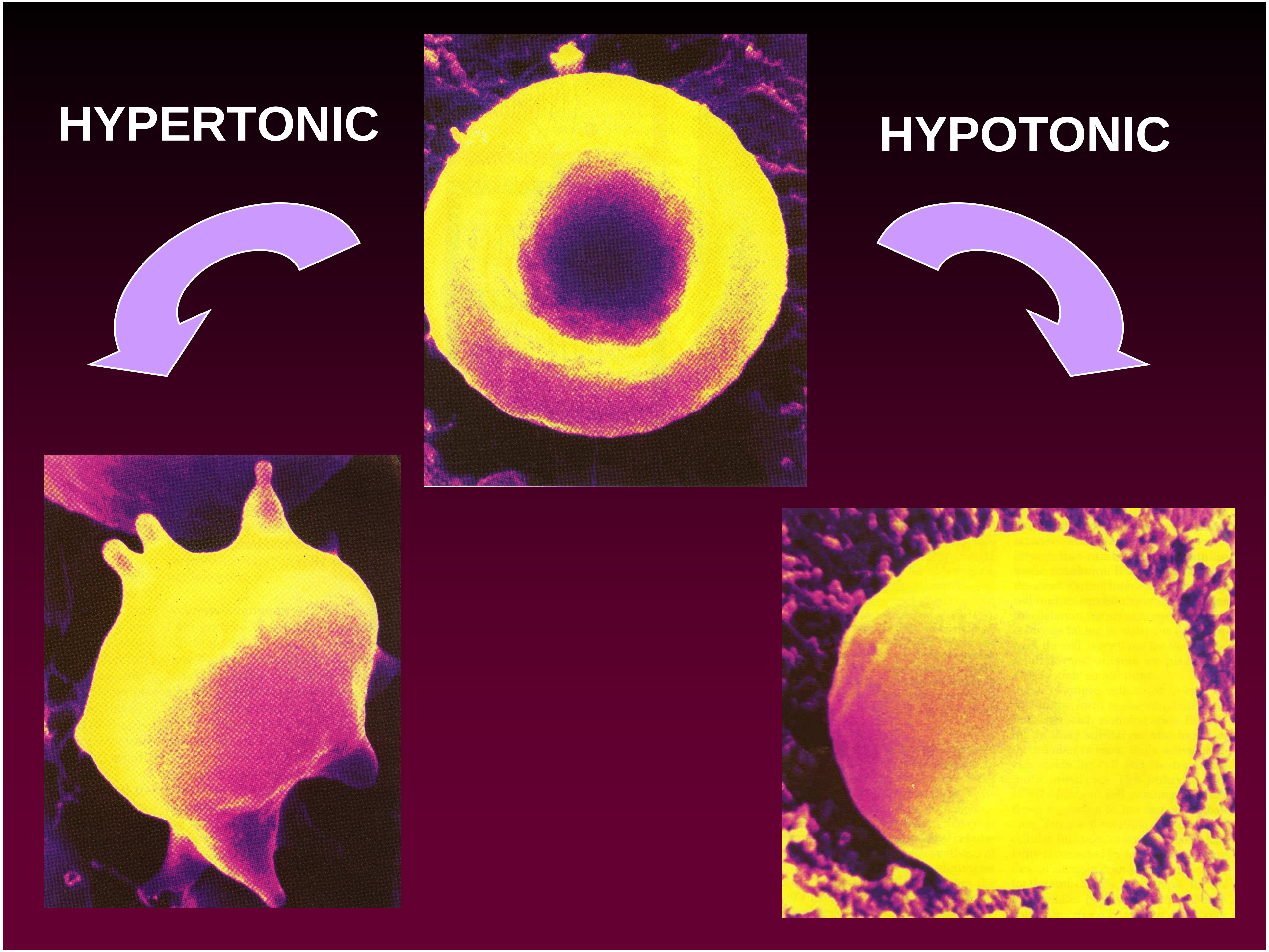


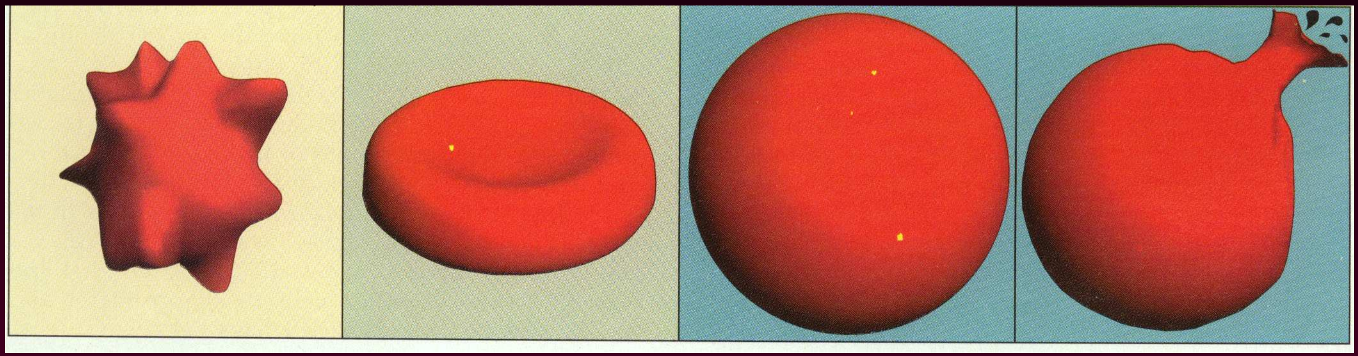
Blood Conc. (mOsm)
1000
500
0
ions
organics
ICF Conc. (mOsm)
1000
500
0
ions
organics
SW invert.
Elasmobranch
Teleost
FW invert.

Regardless of their environment, **all** animals must be capable of maintaining **isosmoticity** between the **ICF** (intracellular fluid) and **ECF** (extracellular fluid).

Regulating ICF osmotic conc. in response to changes in the osmotic conc. of the ECF is called:

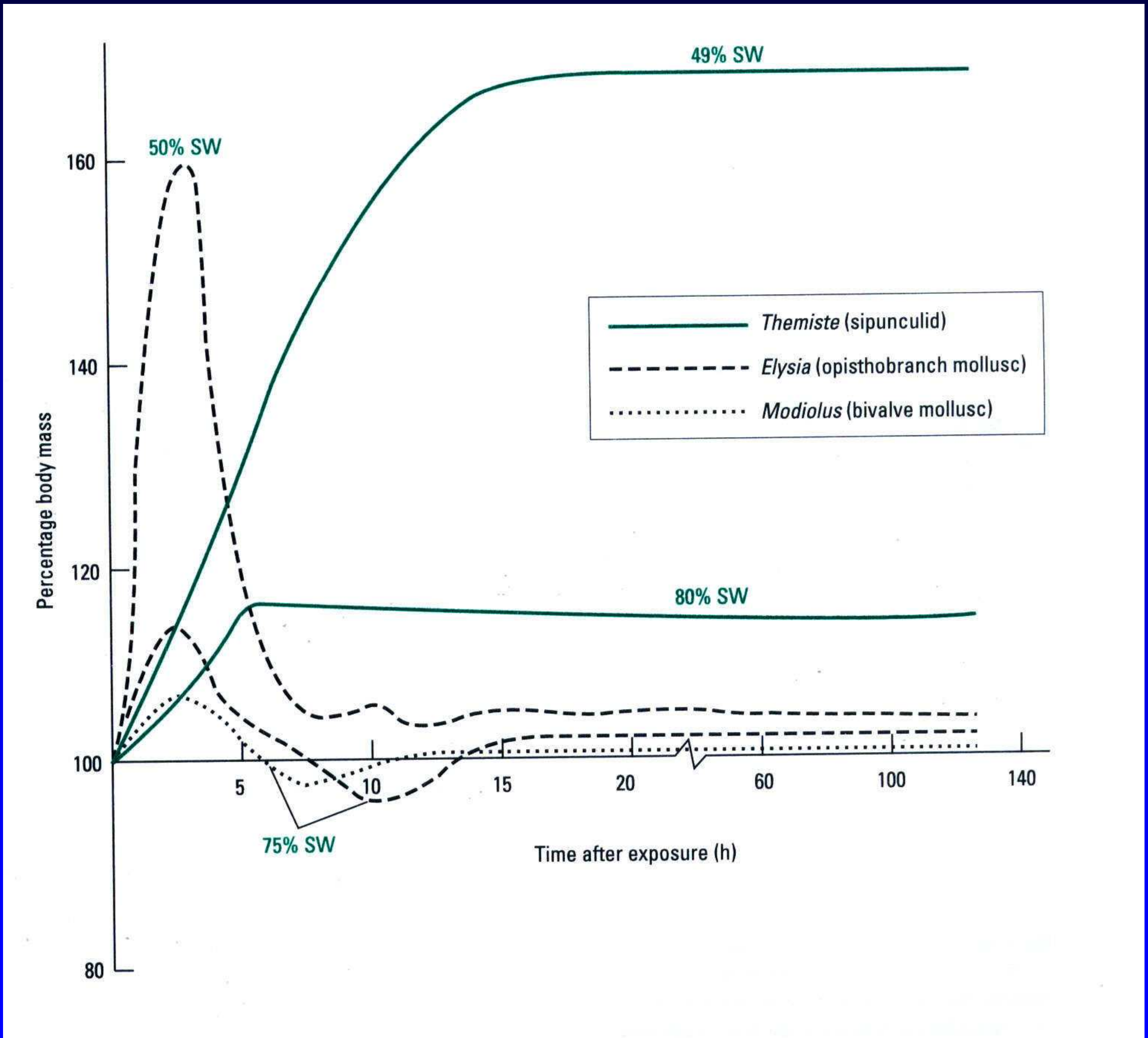
**Cell Volume Regulation**


HYPERTONIC
HYPOTONIC

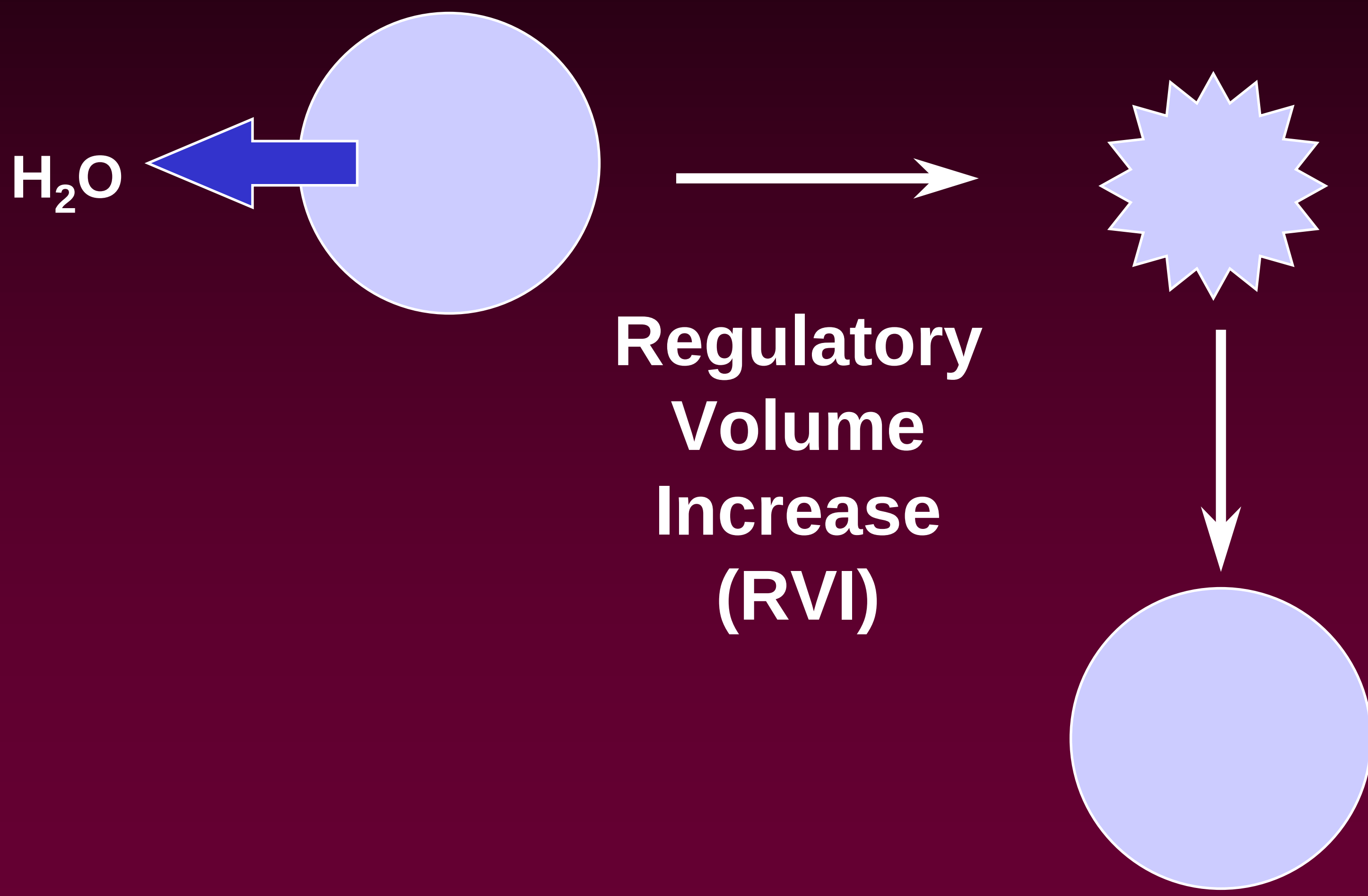


**Unchecked swelling under hypotonic conditions can lead to OSMOTIC LYSIS**

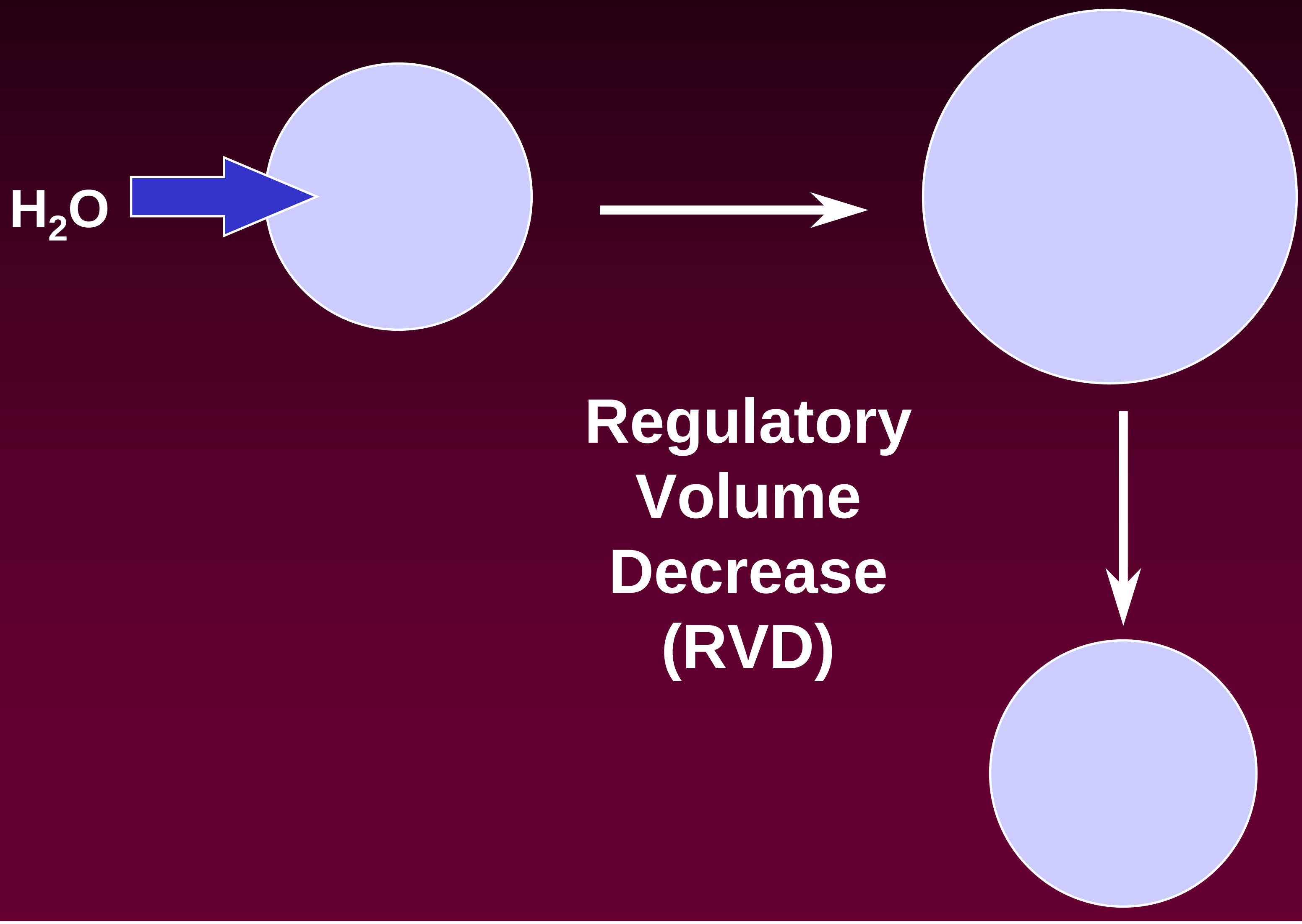
# Volume changes on transfer to dilute seawater



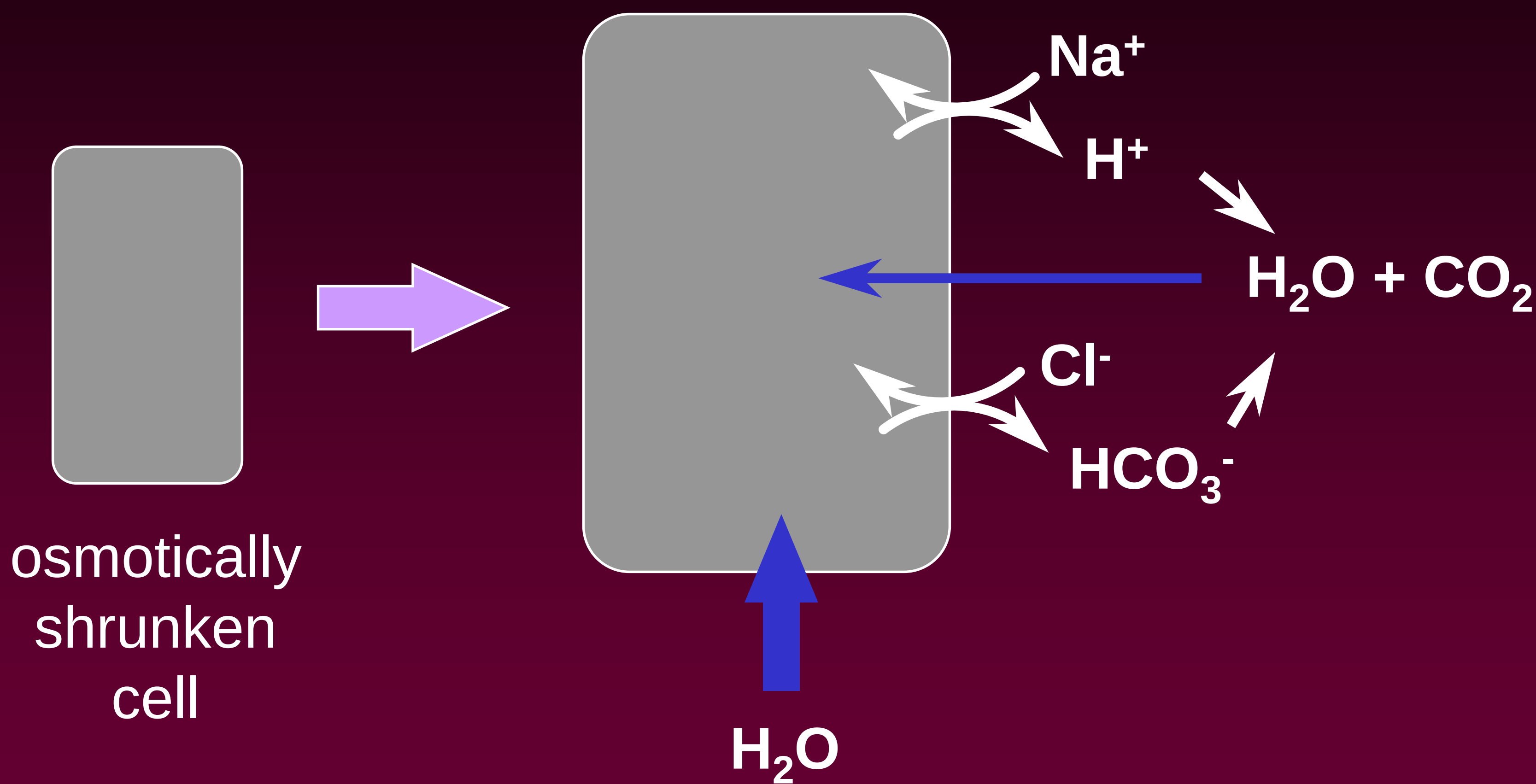
If the osmotic conc. of the ECF increases, water moves out of the ICF and the cell shrinks.



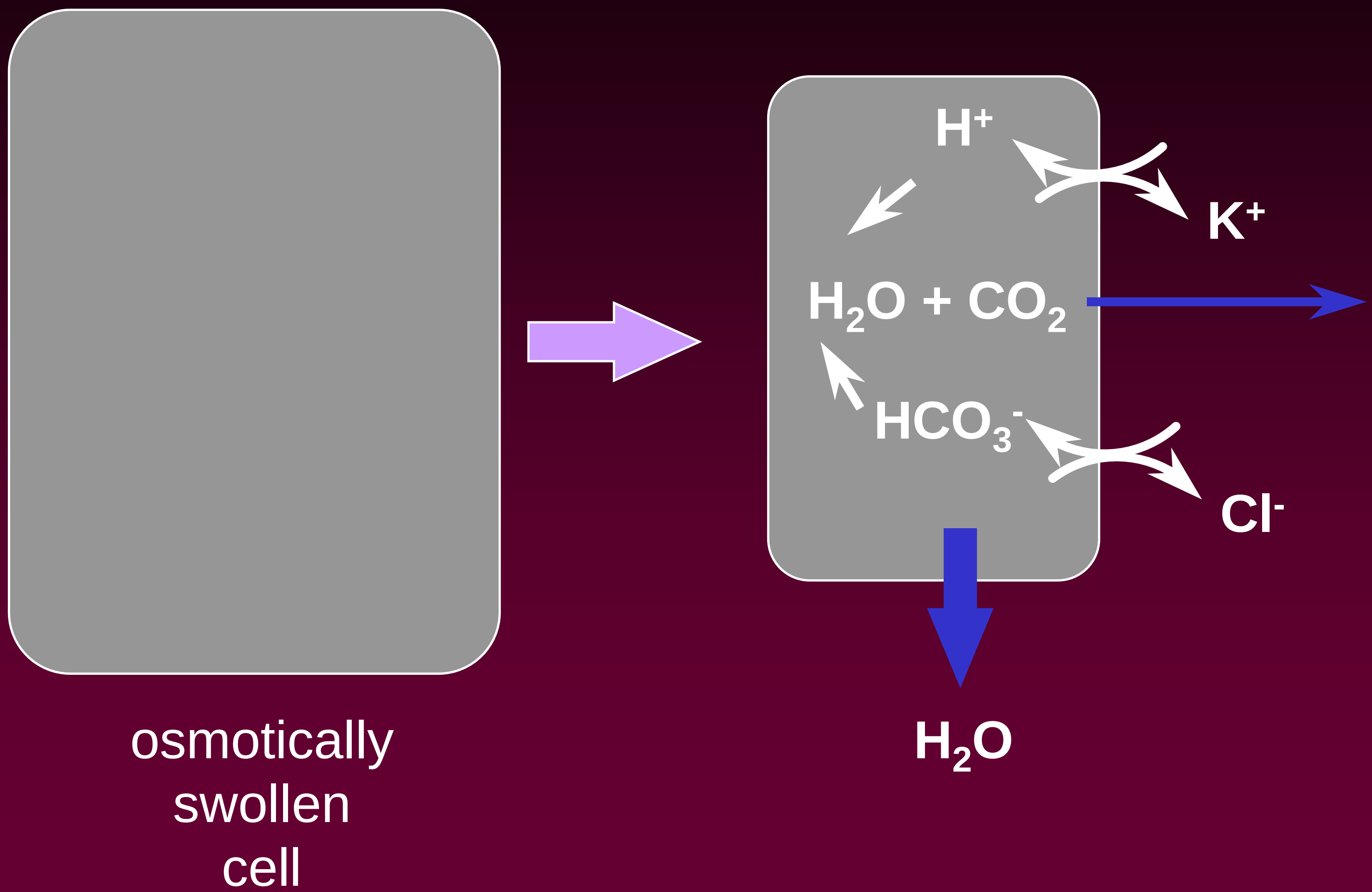
If the osmotic conc. of the ECF decreases, water moves into the ICF and the cell swells.

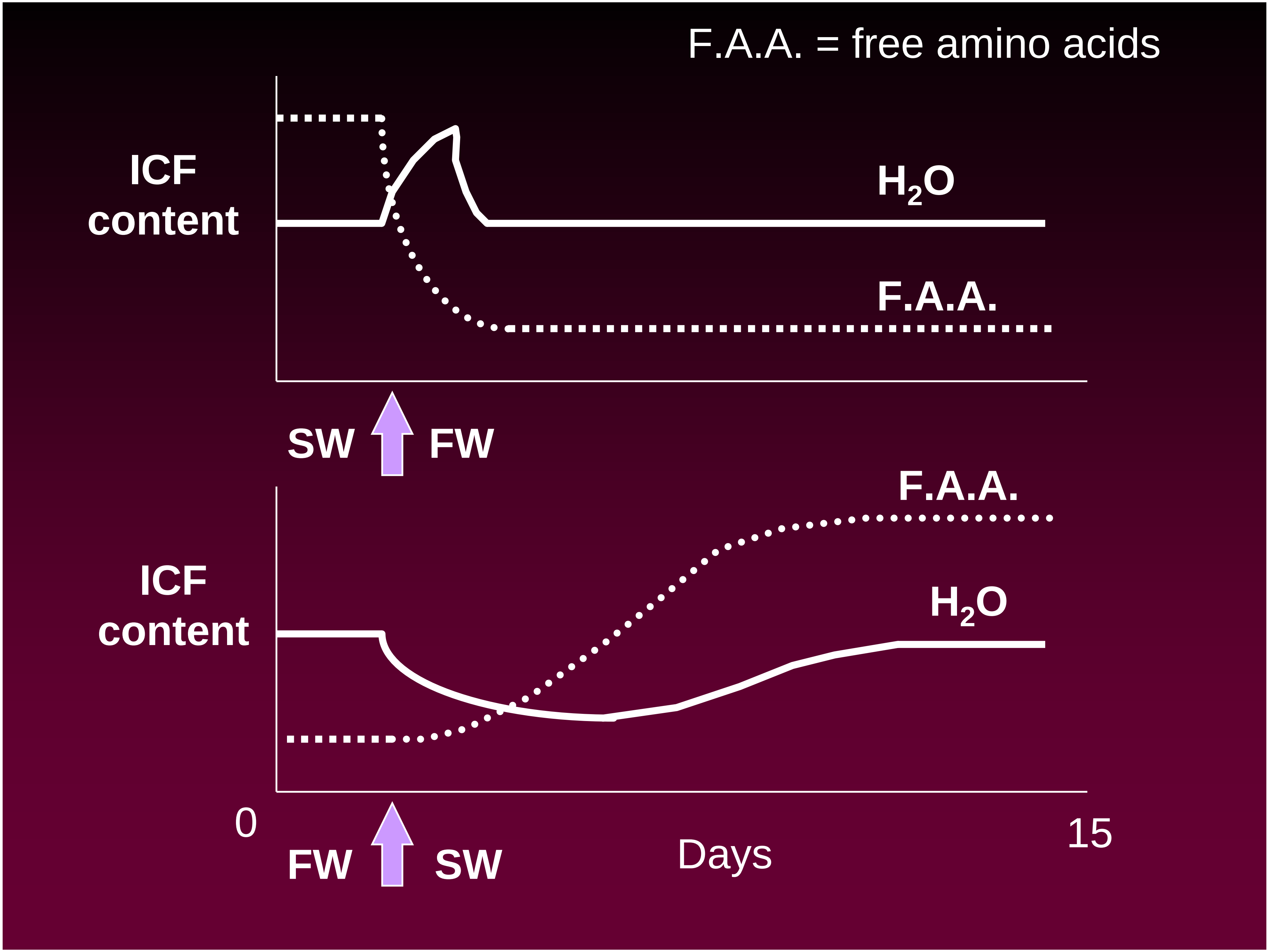


# RVI - Ionic Fluxes



# RVD - Ionic Fluxes

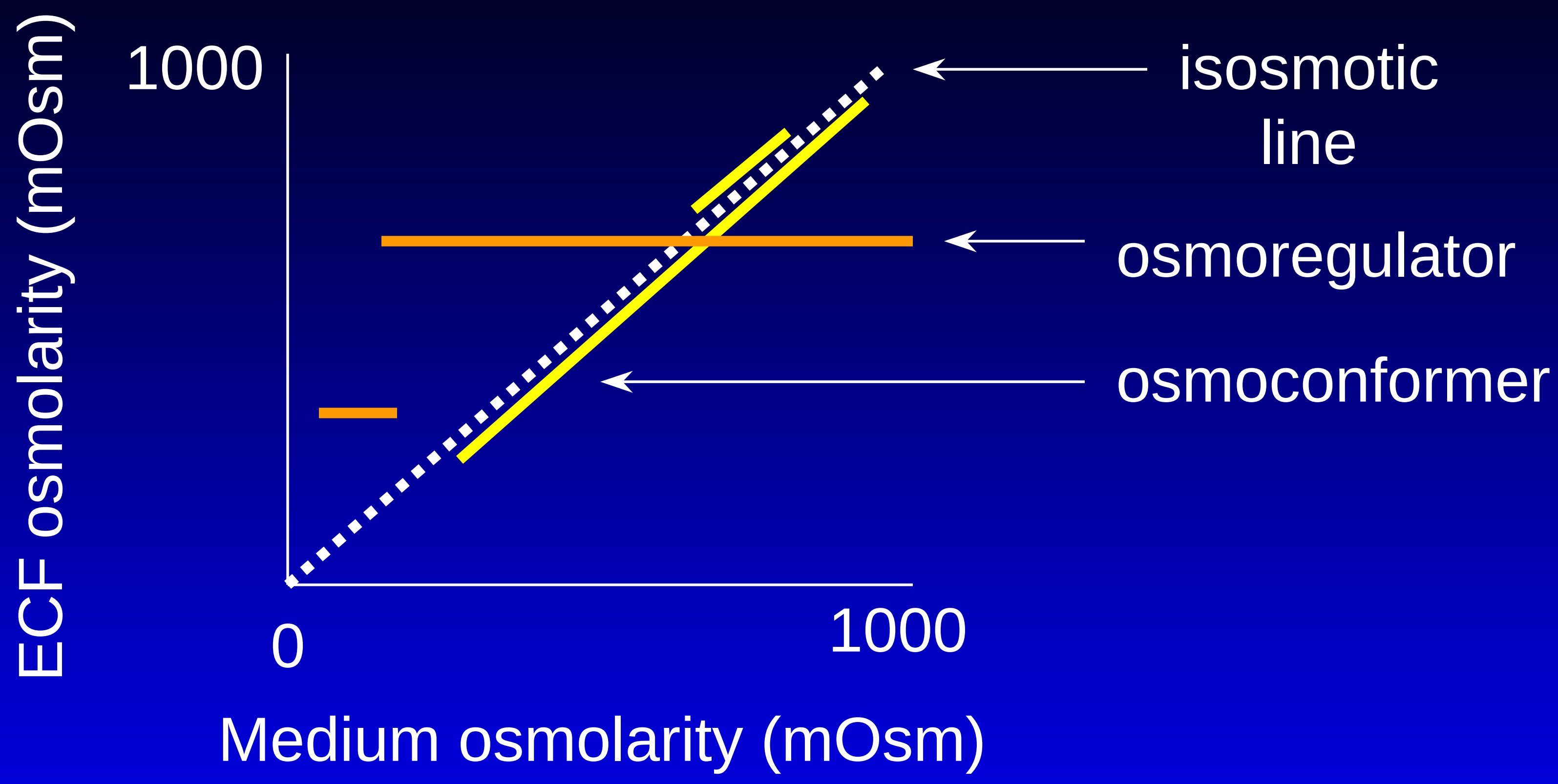



F.A.A. = free amino acids
ICF content
$H_2O$
F.A.A.
SW
FW
F.A.A.
ICF content
$H_2O$
0
15
FW
SW
Days

Animals can reduce the amount of volume regulation their cells must do by regulating ECF osmotic concentrations.

Osmotic and ionic regulation occurs in both aquatic and terrestrial spp.

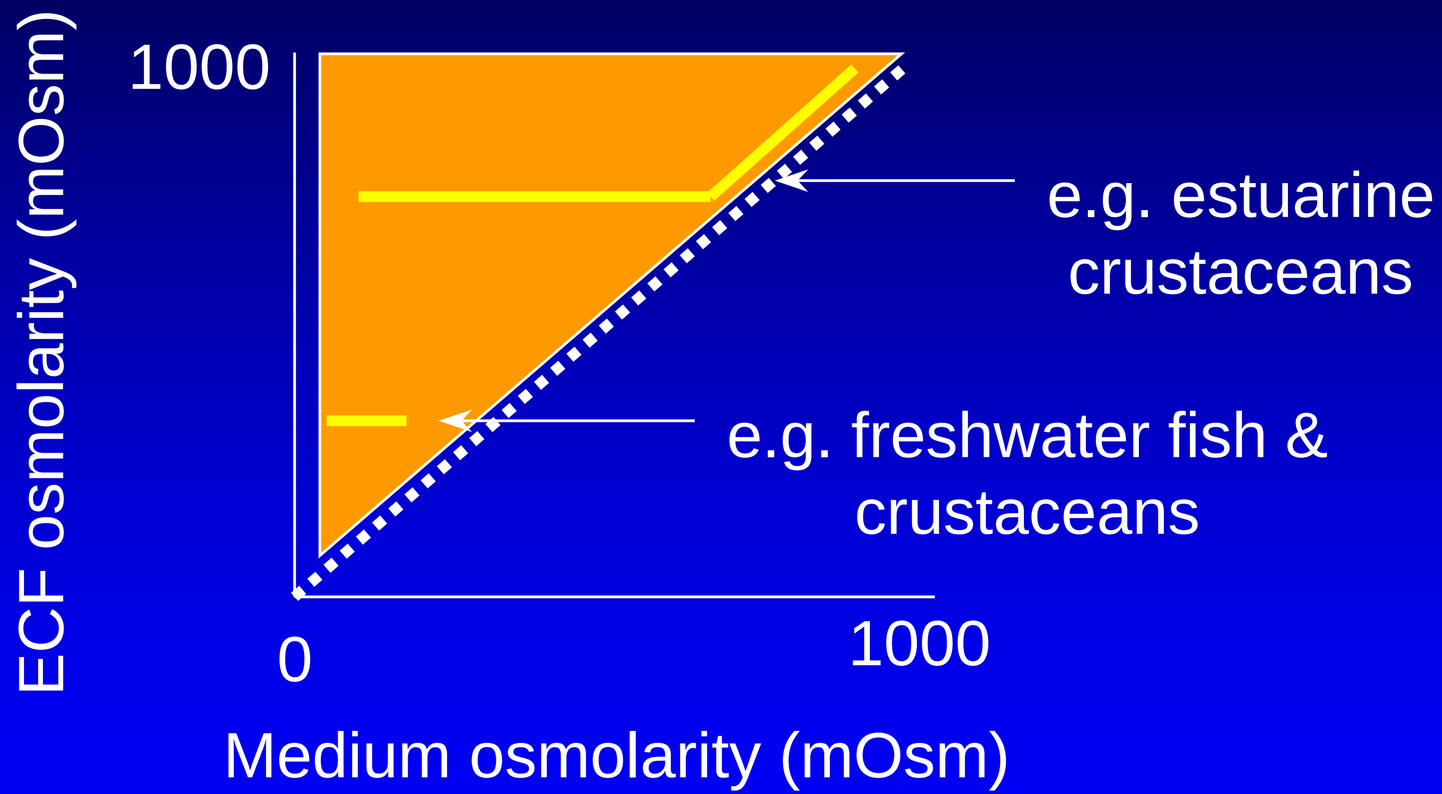
We’ll look at aquatic organisms first

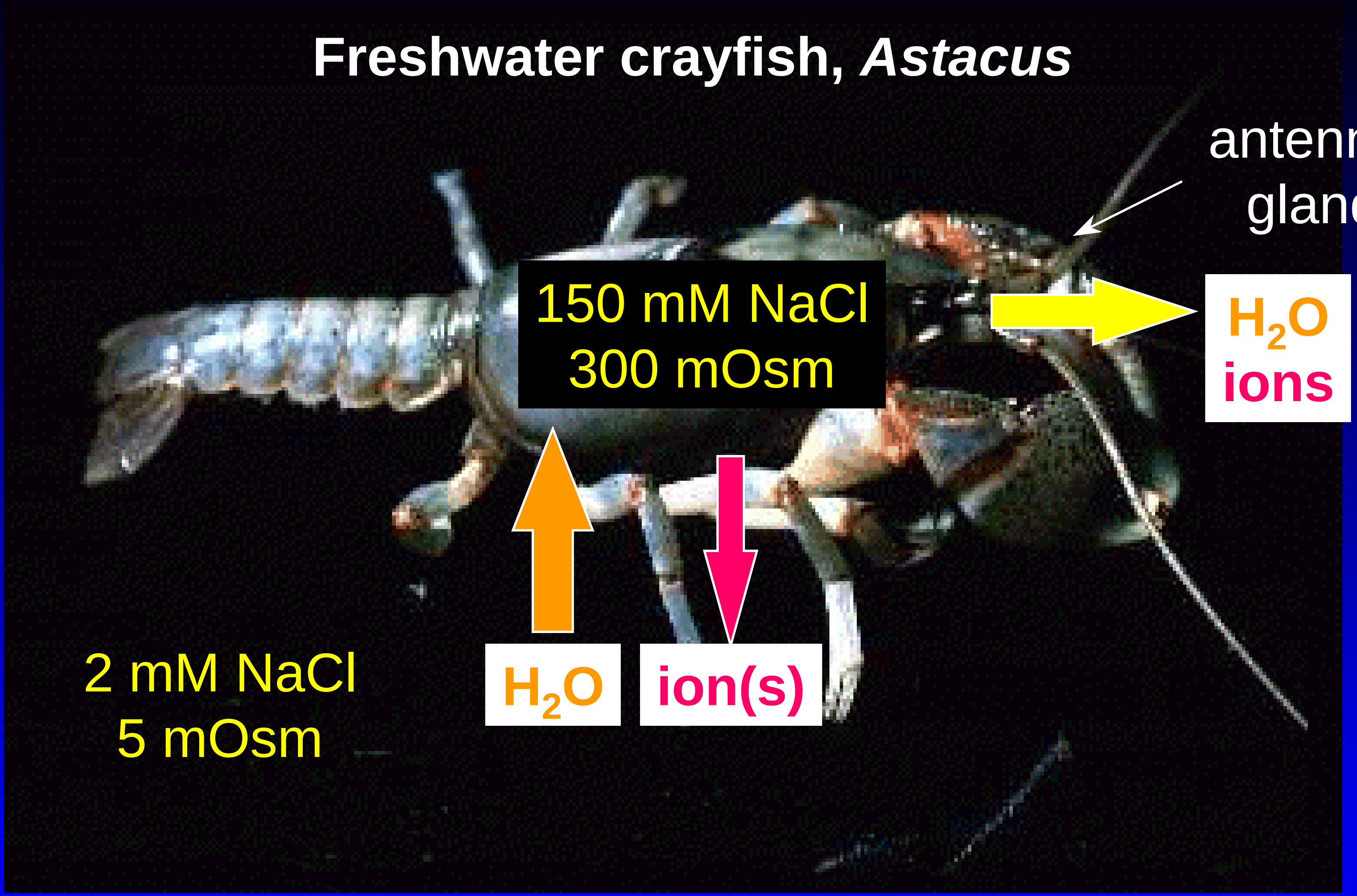



Stenohaline - able to tolerate a narrow salinity range

Euryhaline - able to tolerate a wide salinity range

# Hyperosmotic-Hyperionic Regulation






**Problems:**

- osmotic water gain
- diffusive salt loss
- urinary salt loss

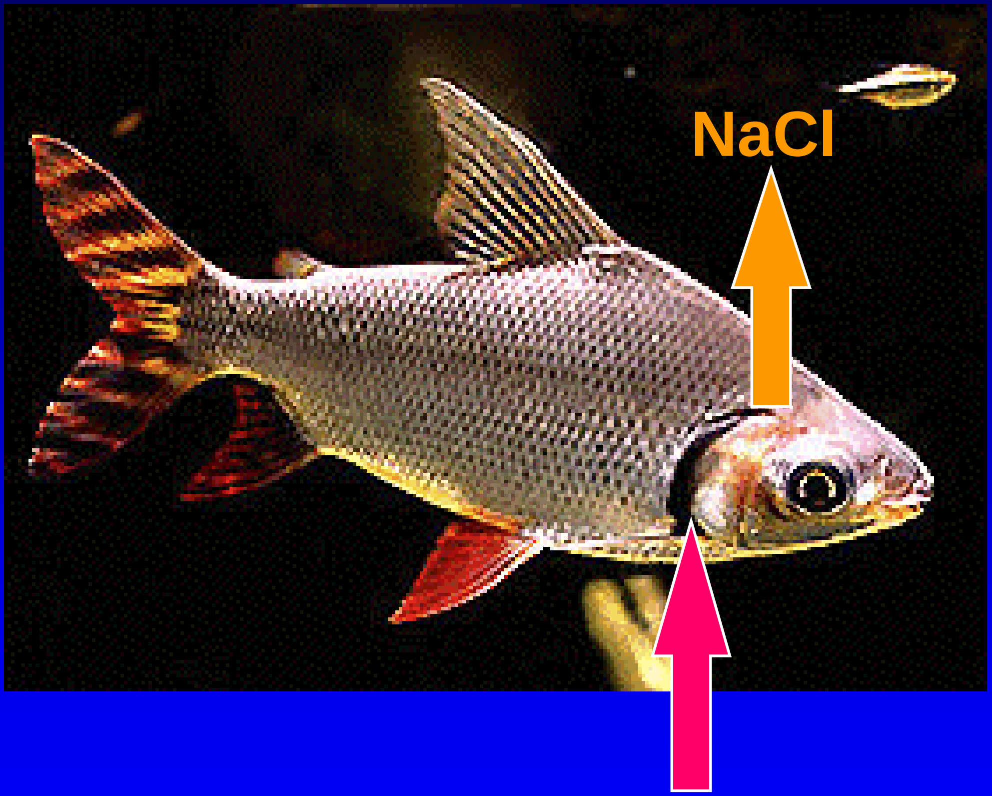
**Solutions:**

- produce copious urine
- decrease permeability
- active ion uptake

## Reduction of gill permeability:

| | $P_{osm}$ ($mosmol^{-1} \cdot h^{-1}$) | $P_{Na}$ ($kg^{-1} \cdot h^{-1}$) |
|---|---|---|
| *Libinia* (sw) | 0.100 | 0.300 |
| *Carcinus* (50% sw) | 0.020 | 0.041 |
| *Astacus* (fw) | 0.009 | 0.001 |

# What is the mechanism for ion uptake in the gills?

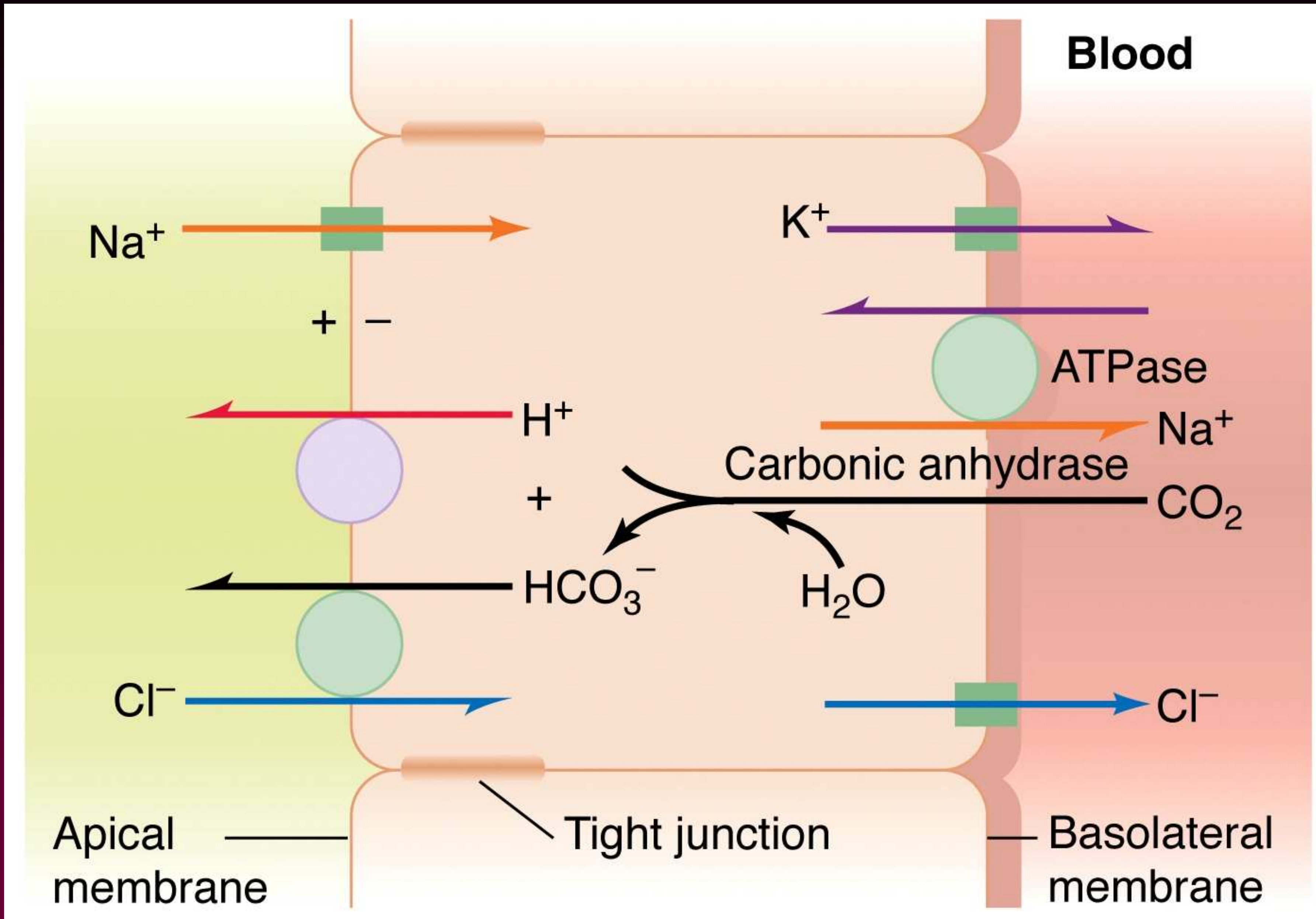



$K^+$ $Na^+$ / $Cl$ $SO_4^{-2}$

If the uptake mechanisms are **independent**, there must be exchange mechanisms:

**$Na^+$ ⟷ cation**

**$Cl^-$ ⟷ anion**


Blood
Na+
K+
+ −
ATPase
H+
Na+
Carbonic anhydrase
+
CO2
HCO3−
H2O
Cl−
Cl−
Apical membrane
Tight junction
Basolateral membrane