

Bio 3303

Animal Physiology I

Prof. Em Standen
Department of Biology
University of Ottawa



BIO 3303 – Animal Physiology I

☐ Dr. Em Standen

- DRO 205, Monday 1:00 - 2:00 pm
Thursday 2:30 – 3:30 pm
- 562-5800 x6044, estanden@uottawa.ca

☐ TA Greg Jensen gjens034@uottawa.ca,

- office hours by appointment except for midterm time which are TBD

☐ Lectures

- Mon. 11:30 am – 1:00 pm, Thurs. 1:00 – 2:30 pm, MRN Auditorium

☐ Course web page

- Blackboard Learn
- Course Outline, contact information etc.
- Lecture handouts
- Sample problems, old midterms and exams

BIO 3303 – Animal Physiology I

Text

- Moyes, CD & Schulte, PM (2008) *Principles of Animal Physiology*. 3rd ed., Pearson, San Francisco. 734 pp.
 - Available at the Agora ~\$187 new, ~\$140 used
 - <http://www.agorabookstore.ca/WINT16/BIO3303>
 - 2 copies on reserve at MRT

Other useful texts (available at MRT)

- Moyes & Schulte (2006) – 1st edition (on reserve)
- Hill, RW, Wyse, GA & Anderson, M (2004) *Animal Physiology*. Sinauer Associates, Sunderland. 770 pp.
- Randall, DJ, Burggren, W & French, K (2002) *Eckert Animal Physiology*, 5th ed. Freeman and Co., New York.

Scientific journals

- See course web page

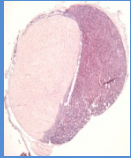
□ Evaluation

- Assignments – 4 worth 10% in total
 - Due Jan. 22nd, Feb. 5th, Mar. 8th and Mar. 24th, 2016
 - To be submitted via Blackboard Learn
- Midterm exams – 2 x 20% each = 40% in total
 - **Thursday, February 11th** and **Thursday, April 4th**, 2016, 80 min each
 - Midterms will not be cumulative
 - Short answer and essay-type (short!) questions
- Final exam - 50%
 - Will cover **all** of the course material
 - Short answer and essay-type (short to long) questions
- No make-up midterms – if absence is justified, component attributed to missed midterm will be added to the final exam.
- Sample/review questions for each topic are posted on the web page, together with old midterms and exams.

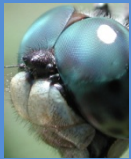
Topics



Control systems I – Nervous system
(Chps. 4 and 7)



Control systems II - Endocrinology
(Ch. 3)



Sensory physiology
(Ch. 6)



Muscles, locomotion and animal energetics
(Chs. 5, 11 and 12)

Lecture Schedule

Date	Lecture	Topic
Jan. 11	1	Introduction to animal physiology
Jan. 14	2	Introduction to nervous systems
Jan. 18	3	Nervous system diversity and organization of the vertebrate NS
Jan. 21	4	Autonomic nervous system
Jan. 22		Assignment #1 Due on Blackboard Learn
Jan. 25	5	Introduction to endocrinology: control of hormone secretion
Jan. 28	6	The hypothalamo-hypophyseal complex
Feb. 1	7	Hormones and stress
Feb. 4	8	Introduction to sensory physiology: basic principles
Feb. 5		Assignment #2 Due on Blackboard Learn
Feb. 8	9	Catch-up time and/or review
Feb. 11		Midterm #1
Feb. 15		READING WEEK
Feb. 18		READING WEEK
Feb. 22	10	Chemoreceptors
Feb. 25	11	Mechanoreceptors
Mar. 29	12	Hearing
Mar. 3	13	Photoreception
Mar. 7	14	Vision
Mar. 8		Assignment #3 Due on Blackboard Learn
Mar. 10	15	Introduction to muscles, locomotion and animal energetics
Mar. 14	16	Muscle function
Mar. 17	17	Muscle heterogeneity
Mar. 21	18	Muscle energetics
Mar. 24	19	Animal energetics and metabolic rate
Mar. 24		Assignment #4 Due on Blackboard Learn
Mar. 28		Easter Break
Mar. 31	20	Catch-up time and/or review
Apr. 4		Midterm #2
Apr. 7	21	Fueling energetics: nutrition and metabolism
Apr. 11	22	Integrating metabolism with energetics

Lecture Objectives

- By the end of this lecture, you should be able to...
 - Define Physiology
 - Know that Physiology has a long history
 - Define the sub disciplines of Physiology
 - Understand the unifying themes of Physiology

Introduction to Physiology

■ What is physiology?

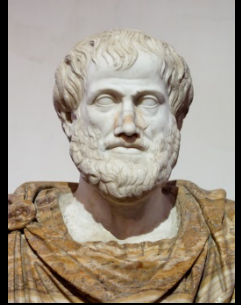
- The study of the function of organisms as integrated systems of molecules, cells, tissues, and organs in normal and diseased states
 - Modified from the American Physiological Society

How organisms work.



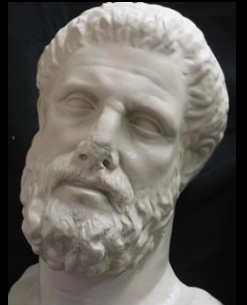
History of Physiology

Aristotle: Father of Natural History (~ 384 BC)



Hippocrates: Father of Medicine (~460 BC)

- Influenced the thinking of those that followed



Galen: Founder of Physiology (~199AD)

- First to design experiments to understand how the body works



Vesalius: (1514-1564)

- First modern anatomy textbook
- Demonstrated that Galen had made errors



History of Physiology

18th century: Bodily functions are a combination of both physical and chemical processes

19th century: Cell Theory, Homeostasis

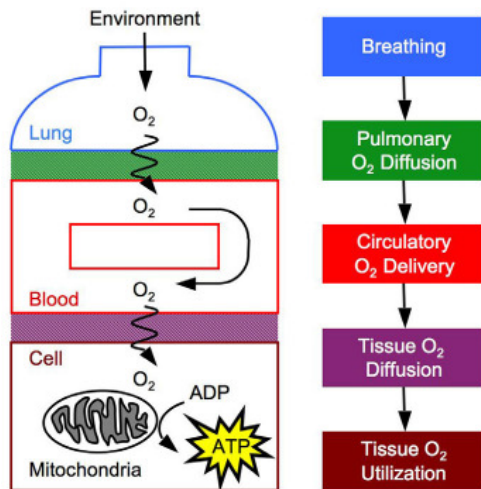
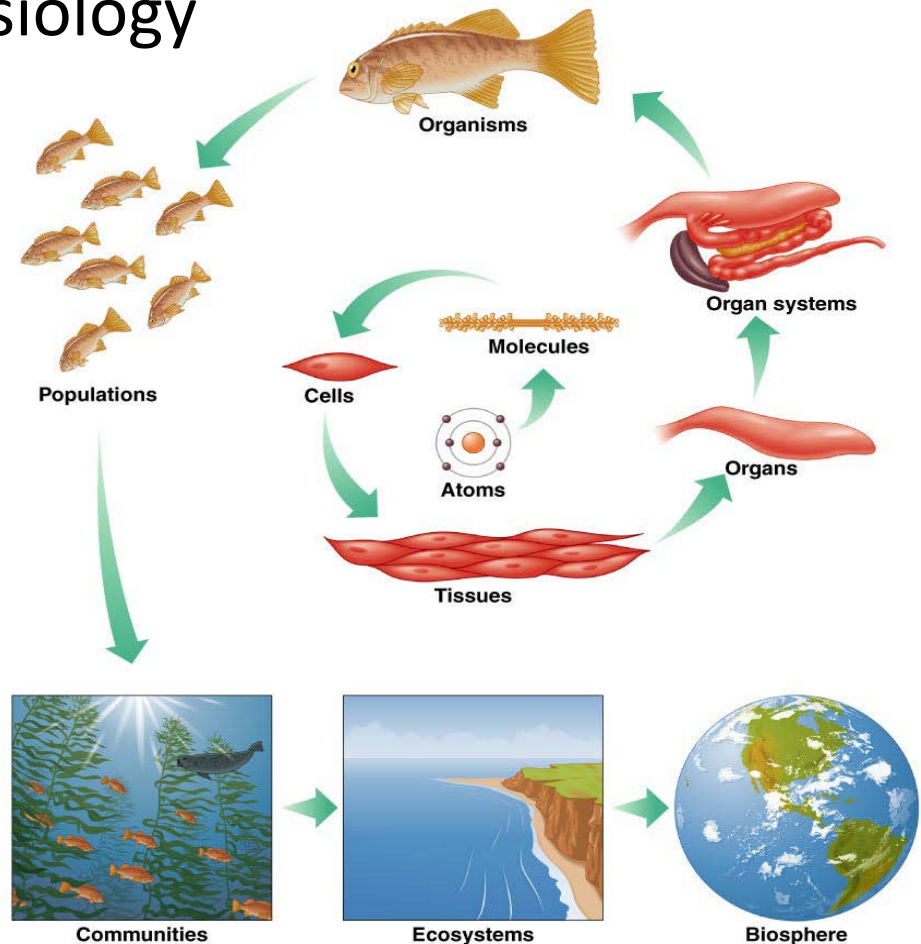
20th century: Comparative physiology

- Scholander (1905-1980): first and most influential comparative physiologist
- Schmidt-Nielsen (1915-2007): how animals live in extreme environments
- George Bartholomew (1923-2006): founder of the field of ecological physiology

Subdisciplines of physiology

A – Levels of biological Organization

- Cell and molecular physiology
- Systems physiology
- Organismal physiology
- Ecological physiology
- Integrative physiology



(Storz et al. 2010)

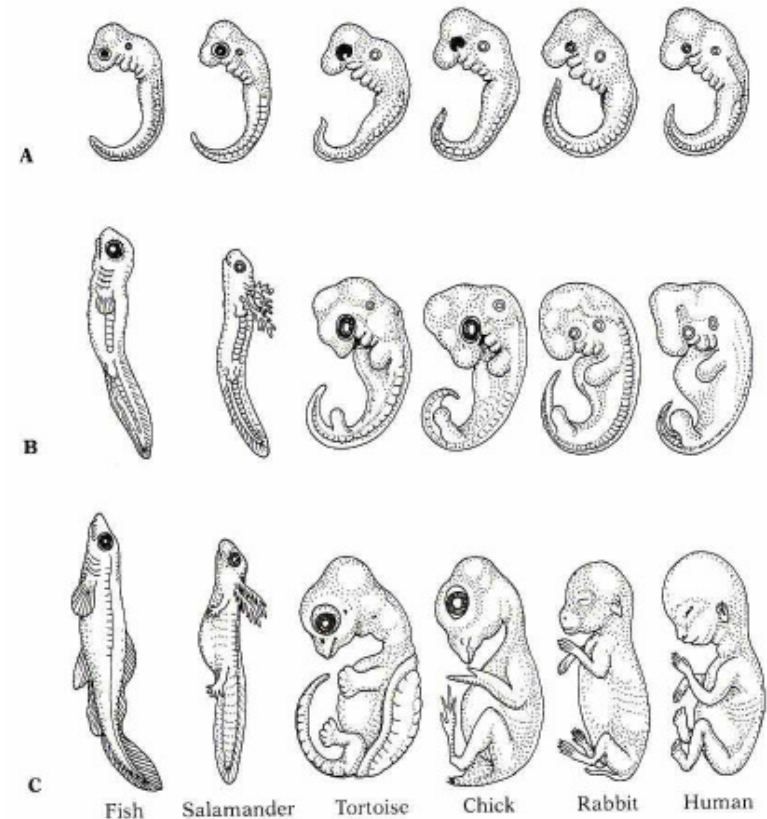
Subdisciplines of physiology

B – Processes that generate variation

- Developmental physiology
- Evolutionary physiology
- Environmental physiology

C – Ultimate goals of the research

- Applied physiology
- Comparative physiology



Unifying Themes in Physiology

1. Physiological processes obey the laws of chemistry and physics
2. Physiological systems are tightly regulated
3. The physiological phenotype is a product of the genotype and the environment
4. Physiological diversity is the result of evolutionary processes

1 - Physiological processes obey laws of chemistry and physics

- Chemical laws govern interactions between biological molecules
 - E.g. weak bonds are sensitive to temperature

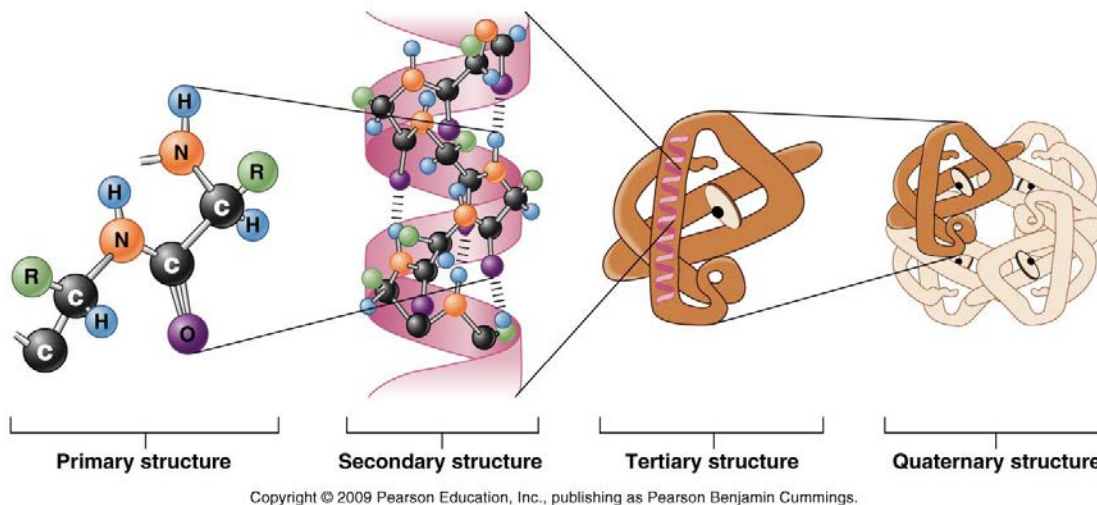
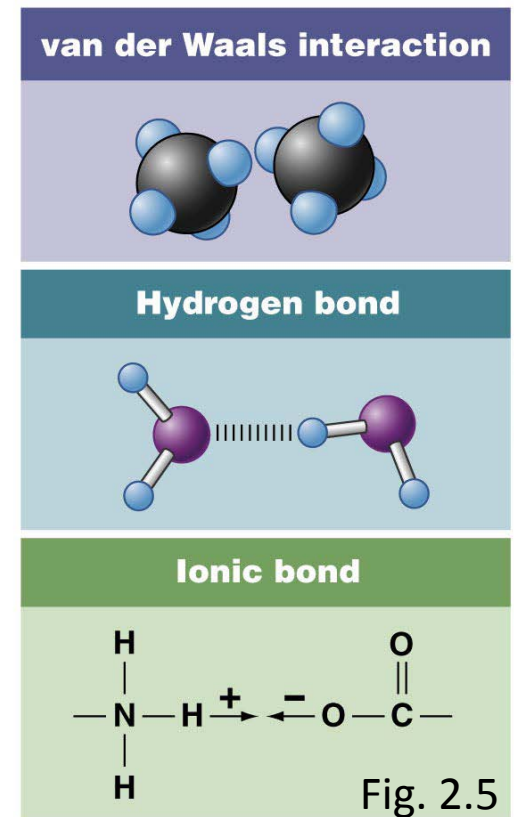


Figure 2.20



1 - Physiological processes obey laws of chemistry and physics

- Mechanical concepts apply to physiological systems
 - E.g. flow, pressure, resistance, strain, fluid dynamics, etc.
- Animals use electricity to drive processes
 - Cells establish charge differences across biological membranes by moving ions and molecules to create ionic and electrical gradients

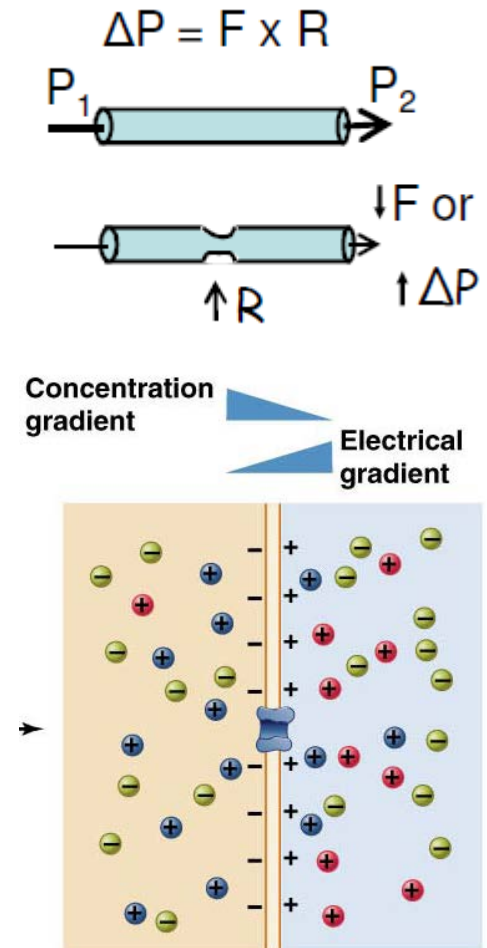
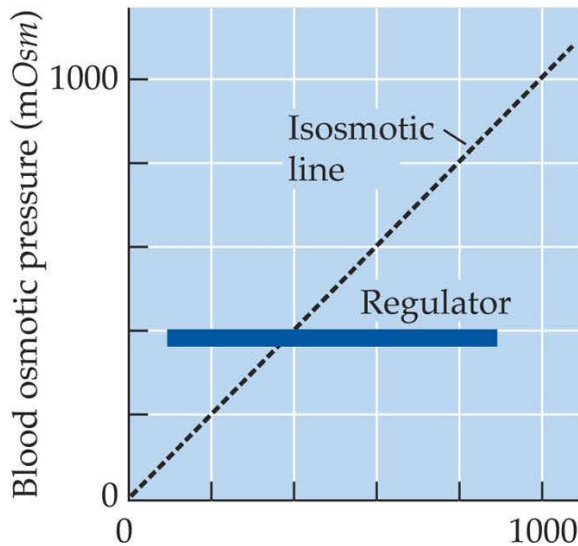


Fig. 2.50

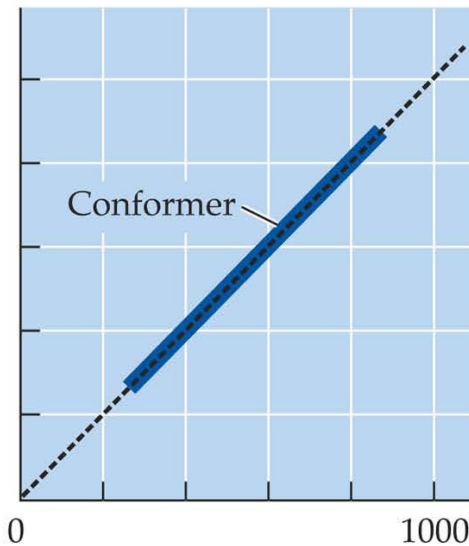
2 - Physiological systems are tightly regulated

- Two strategies for dealing with environmental changes
 - Conformers: allow internal conditions to change with variation in external conditions
 - Regulators: maintain constant internal conditions regardless of the external conditions. → **Homeostasis**

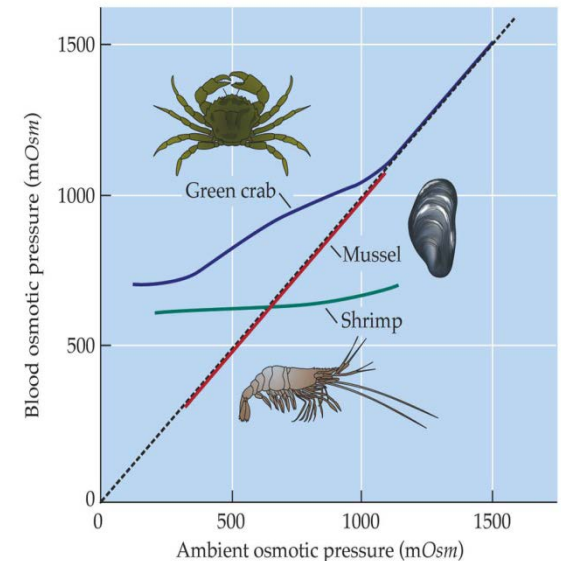
(a) Osmotic regulation (idealized)



(b) Osmotic conformity (idealized)

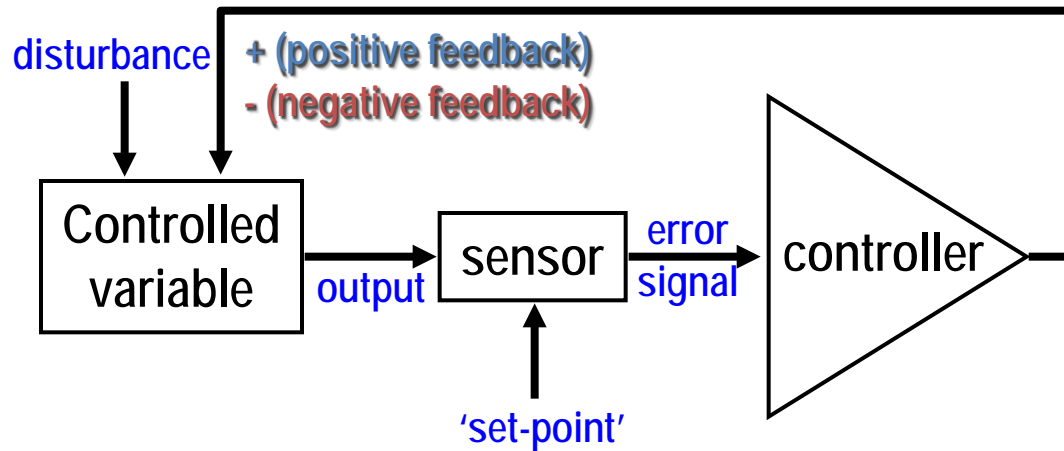


(c) actual animals

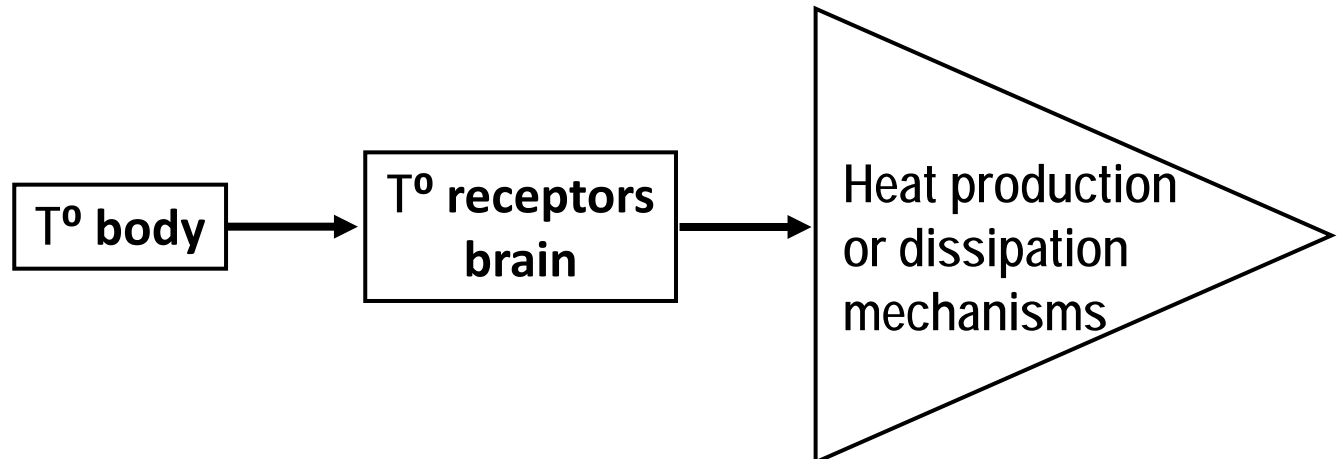


2 - Physiological systems are tightly regulated

Negative and Positive feedback loops



For example:



2 - Physiological systems are tightly regulated

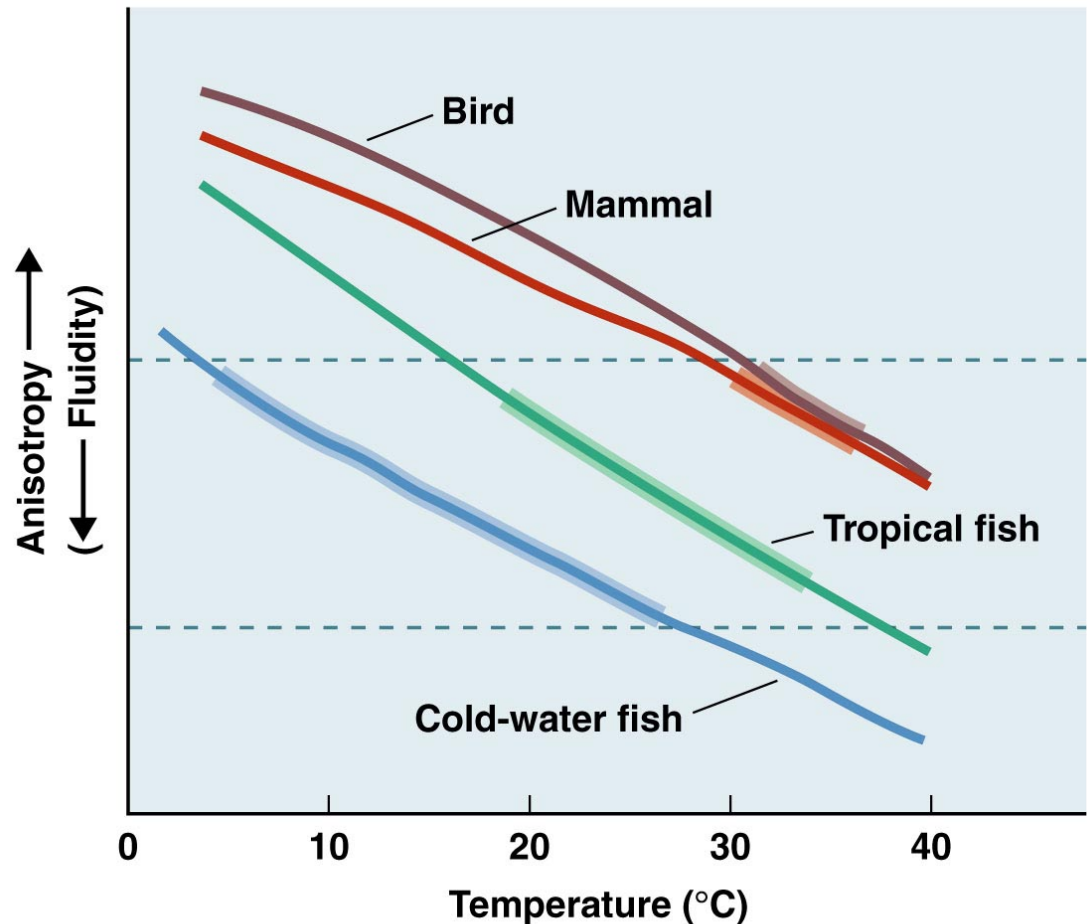
Homeostasis vs. Enantiostasis

Homeostasis: maintenance of a constant internal state (e.g. body T° in mammals = 37°C)

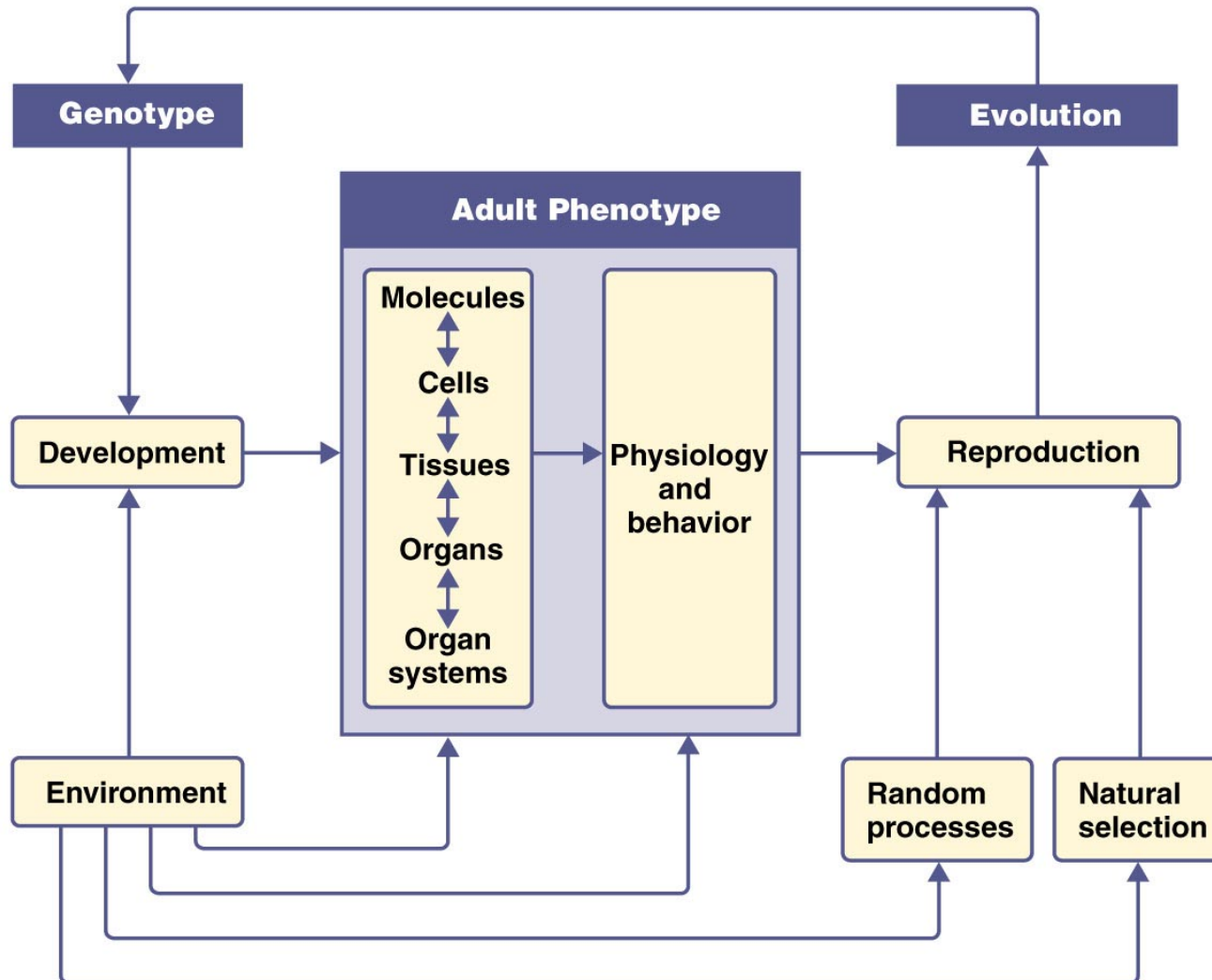
Enantiostasis:

maintenance of function when physiological variables are changing

- E.g. Maintaining membrane fluidity at different T° (functions retained)



3 – Phenotypes result from the genotype and the environment



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3 – Single genotype can result in more than one phenotype

Phenotypic plasticity: production of different phenotypes by a single genotype as a result of environmental changes.

→ Physiological changes can be reversible or irreversible

- Reversible physiological changes:

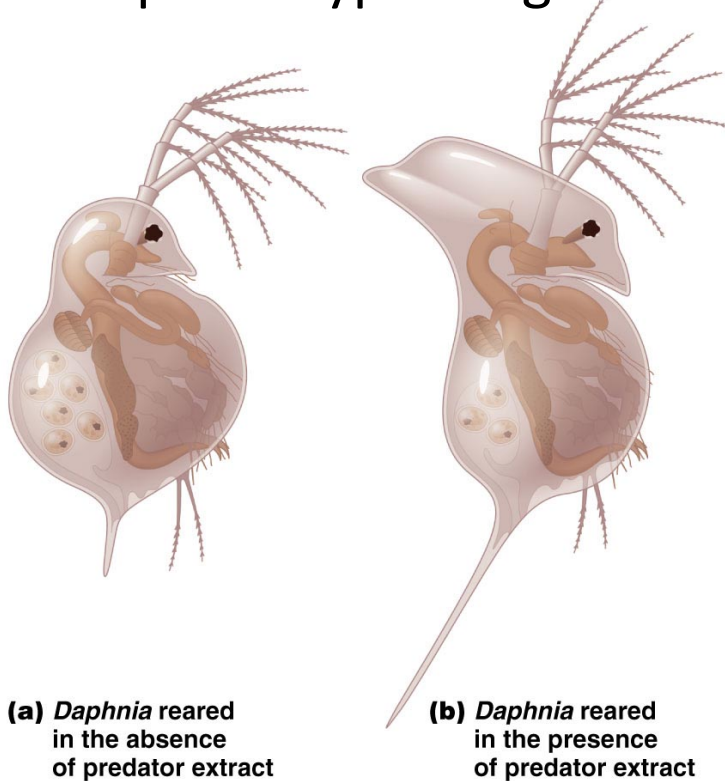
Acclimatization: process of physiological change in response to naturally changing environmental conditions

Acclimation: process of physiological change in response to a controlled or manipulated environmental variable (under laboratory conditions)

3 – Phenotypic plasticity

- **Irreversible physiological changes**

Polyphenism (developmental plasticity): development under different conditions results in different adult phenotypes. E.g. Water fleas (*Daphnia*)



(a) *Daphnia* reared in the absence of predator extract

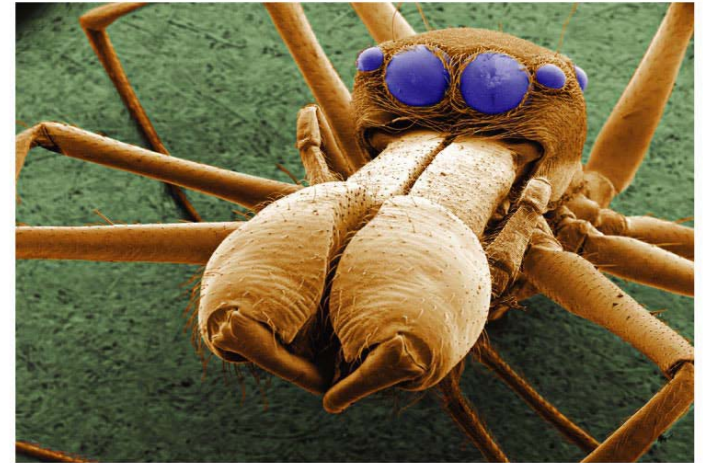
(b) *Daphnia* reared in the presence of predator extract

Reaction norm: the range of phenotypes that can be produced by a given genotype when it is exposed to different environments

Fig. 1.5

4 – Physiological diversity is the result of evolutionary processes

- **Physiological systems show tremendous variability**
 - Variability arises through adaptive and random evolutionary processes



Adaptation: change in the genetic structure of a population as a result of natural selection

- **Do not** use adaptation in the context of phenotypic plasticity: beneficial change that occurs over the course of a lifetime (e.g. exercise).



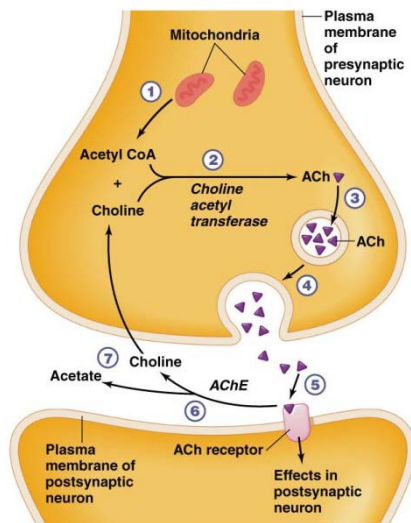
4 – Physiological Adaptations

Requirements for adaptive evolutionary change:

- 1 – Must be variation among individuals in the trait
- 2 – Trait must be heritable
- 3 – Trait must increase fitness
- 4 – Relative fitness of different genotypes depends on environmental conditions

e.g. Insecticide resistance

- Individuals with mutations conferring resistance to neurotoxic insecticides survive and reproduce



Organo-phosphates →

~~Neurotransmitter (acetylcholinesterase)~~

→ Converts toxin

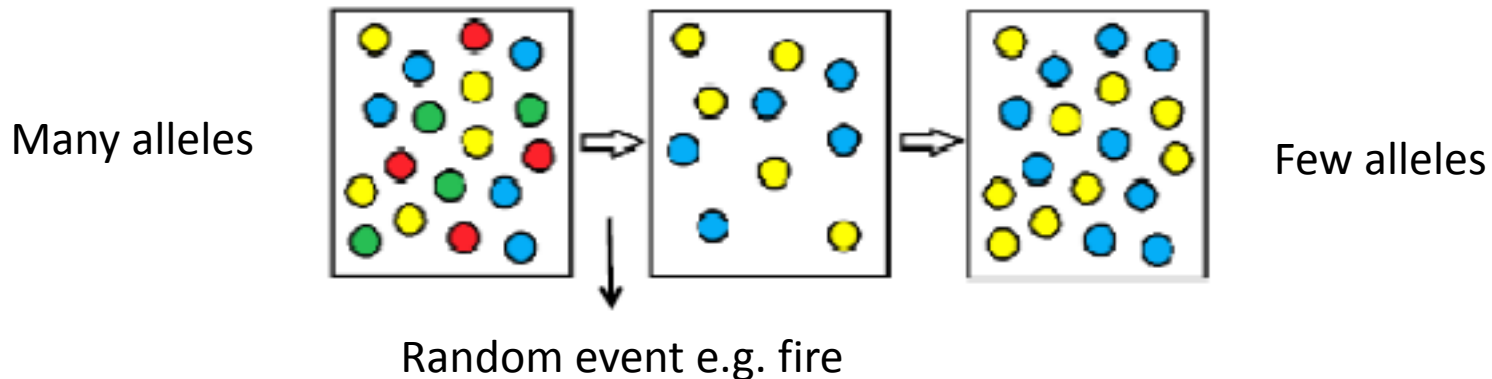


→ Tolerates toxin

Fig. 4.17

4 – Physiological Diversity is the result of evolutionary processes

- Some variations are not adaptive
 - Genetic frequencies can change due to random events (genetic drift: e.g. population bottleneck)



- Evolutionary relationships predict morphological, physiological and behavioural similarities
 - Closely-related species have more similarities in physiological systems than distantly-related ones

Key Points

- Physiology is...
 - A discipline with a long history and tradition
 - Focussed on all levels of biological organization from molecular to ecological
 - The basis of integrative biology, in that physiology is the link between genes and behaviour
 - Incredibly diverse, but based upon a number of unifying themes