

1 ☐ **Chapter 20 - Unifying Concepts of Animal Structure & Function**

2 ☐ **Introduction**

- Does evolution lead to the perfect animal form?
- Physical structures are adaptations
 - Enhance an animal's chances of survival and reproduction
- Correlation of structure and function – major theme of bio
-
- Animal structures
 - often just “good enough” to function
 - not the ultimate in design

3 ☐ **An Evolutionary Connection between Anatomy & Physiology**

- An animal's form is not the perfect design
-
- Example:
 - The laryngeal nerve of an adult giraffe travels from the brain, makes a U-turn around the aorta in the chest, and then extends back up the neck to muscles in the throat.
 - The throat is about 1 foot away from the brain.
 - Why, then, does the laryngeal nerve make about a 15-foot journey?

4 ☐ **An animal's form is not the perfect design**

- Adaptations that led to the varying lengths of the laryngeal nerve in tetrapods can be illustrated with an analogy.
- If a table is moved away from an outlet, two options are obvious for plugging in the lamp:

5 ☐ **Laryngeal Nerve = Evolutionary Adaptation?**

- The early embryos of fish and tetrapods are very similar.
- In their embryos, the laryngeal nerve connects the brain to a rudimentary structure that in:
 - fish = gills
 - tetrapods = larynx.
- In these embryos, the nerve hooks under the aorta.
 - This is not problematic in fish because they do not have necks.
 - But in tetrapods, the aorta ends up in the chest, resulting in an elongated laryngeal nerve in tetrapods.
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STRUCTURE AND FUNCTION IN ANIMAL TISSUES

9 ☐ **Form vs. Function**

- Anatomy
 - Study of body's internal and external structures, and relationship between body's parts
 - Traditionally subdivided into gross & microscopic
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- Physiology
 - Study of how these structures work as an integrated whole
 - Focuses on the chemical, electrical & physical process of the body
 - Traditionally deals with on organs and organ systems
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- Anatomy affects physiology

10 ☐ **Form Follows Function**

- Think about the shape of organisms bodies
- Example:
 - Seals, whales, sharks and penguins have streamlined, tapered bodies
 - Why? Why don't you?
 - How does this effect their physiology?

11 ☐ **Structure fits function at all levels of organization in the animal body**

- Animals consist of a hierarchy of levels of organization.
 - Tissues – an integrated group of similar cells that perform a common function.
 - Organs - perform a specific task and consist of two or more tissues.
 - Organ systems - consist of multiple organs that together perform a vital body function.

12 ☐ **The structural hierarchy of animals**

13 ☐ **Basics of Tissues**

- Tissues
 - Similar cells with a common function
 - Tissue + Tissue = organ
- Animals have four main categories of tissues:
 - epithelial tissue

- connective tissue
- muscle tissue
- nervous tissue.

14 ☐ **Tissue Type: Epithelial**

- What is Epithelial tissues (or epithelia)?
 - are sheets of closely packed cells
- Function:
 - Lining, protection, transport, secretion and absorption
 -
- Where is it located?
 - cover body surfaces
 - line internal organs and cavities

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16 ☐ **Types of epithelial tissue**

17 ☐ **Examples of Real Epithelial Tissue**

18 ☐ **Tissue Type: Connective**

- What is connective tissue?
 - are sheets of closely packed cells
- Function:
 - Support and reinforce other tissues
 -
- Where is it located?
 - within or between other tissue layers
 - Within most organs

19 ☐ **Examples of Connective Tissue**

20 ☐ **Types of Connective Tissue**

- Connective tissue can be grouped into six major types.
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- Loose connective tissue
 - most widespread
 - consists of ropelike collagen & elastin fibers that are strong and resilient
 - helps to join skin to underlying tissues
 -
- Fibrous connective tissue
 - Comprised of only densely packed collagen fibers only
 - forms tendons that attach muscle to bone.

21 ☐ **Types of Connective Tissue cont.**

- Adipose tissue
 - made of adipocytes
 - stores fat in large, closely packed cells held in a matrix of fibers
 - # of cells comprising this tissue traditionally does not change throughout an individual's lifetime
- Cartilage
 - made of chondrocytes
 - a strong and flexible skeletal material
 - commonly surrounds the ends of bones (a joints)
 - Provides cushioning

22 ☐ **Types of Connective Tissue cont.**

- Bone
 - comprised of osteocytes
 - a matrix of collagen fibers embedded in a hard mineral substance containing:
 - calcium, magnesium, and phosphate.
- Blood
 - comprised of:
 - Blood cells
 - Erythrocytes = RBCs
 - Leukocytes = WBCs
 - Platelets
 - Plasma
 - transports substances throughout the body.

23 ☐ **Types of Tissue: Muscle**

- Most abundant tissue in most animals.
- Consist of elongated cells that can contract and cause movement.
- Function:
 - Refer above to definition.
- Location in the Body:
 - Varies depending on the classification (structure) of the tissue

24 ☐ **Types of Muscle Tissue**25 ☐ **Types of Muscle Tissue**

26 ☐ **Types of Tissue: Nervous**

- Nervous tissue forms a communication network
-
- Function:
 - Senses stimuli and rapidly transmits information.
 - Receive, integrate and store information, as well as control muscles and glands.
- Location in the Body:
 - Brain, spinal cord, sensory organs, peripheral nerves
 -

27 ☐28 ☐

ORGANS AND
ORGAN SYSTEMS

29 ☐ **Organs are made up of tissues**

- Each tissue performs specific functions.
-
- Most organs are made up of multiple tissue types.
-
- Example:
 - The heart has:
 - Epithelial tissues = provides a smooth inner lining
 - Connective tissues = provides strength & elasticity
 - Muscle = generates contractions
 - Nervous = conductivity

30 ☐ **Another example of multiple tissues = an organ**

- The small intestine:
 - Epithelial tissues = provides a smooth inner lining
 - Connective tissues = contains blood vessels
 - Muscle = generates contractions
 -

31 ☐ **Bioengineers & Their Correlation to Tissues and Organs**

- Bioengineering is seeking ways to repair or replace damaged tissues and organs.
-
- But how?
 - New tissues and organs are being grown on a scaffold of connective tissue from donated organs.
 - Or using desktop printers to create layers of different cells resembling the structure of organs.

32 ☐ **Basics of Organ Systems**

- ~12 total in the mammalian body
-
- Each organ system typically
 - consists of many organs
 - has one or more functions
 - works with other organ systems to create a functional organism.

33 ☐ **Organ systems work together to perform life's functions**

- The integumentary system
-
- Consists of:
 - Hair, Skin & Nails
-
- Protects against
 - physical injury
 - infection
 - excessive heat or cold
 - drying out.

34 ☐ **Organ systems work together to perform life's functions**

- The skeletal system
 - supports the body
 - protects organs (e.g. brain & lungs)
 - provides the framework for muscle movement.
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- The muscular system
 - moves the body & maintains posture
 - produces heat

35 ☐ **Circulatory vs. Respiratory Systems**

- The circulatory system
 - delivers O₂ and nutrients to body cells
 - transports CO₂ to the lungs
 - carries metabolic wastes to the kidneys.
-
- The respiratory system
 - exchanges gases with the environment
 - supplying the blood with oxygen
 - disposing of carbon dioxide.

36 ☐ **Urinary vs. Digestive Systems**

- The urinary system
 - removes waste products from the blood

- excretes urine
- regulates the chemical makeup, pH, and water balance of blood.
- The digestive system
 - ingests and digests food
 - absorbs nutrients
 - eliminates undigested material.
 -

37 ☐ **Endocrine, Lymphatic & Immune Systems**

- The endocrine system
 - secretes hormones that regulate body activities.
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- The lymphatic and immune systems
 - protect the body from infection and cancer
 - returns excess body fluid to the circulatory system.
 -

38 ☐ **The Nervous System**

- Consists of:
 - Neurons = Nerves, Neuroglia
 - Brain & Spinal Cord
 - Sensory organs
 -
- coordinates body activities by:
 - detecting stimuli
 - integrating information
 - directing responses.

39 ☐ **The Reproductive System**

- The reproductive system produces
 - gametes and sex hormones.
 -
- The female reproductive system
 - supports a developing embryo
 - produces milk.

40 ☐

LET'S DIVE A LITTLE DEEPER INTO THOSE BODY SYSTEMS

41 ☐

42 ☐ **The Epidermis**

- Forms the surface of the skin
-

- Area of rapid cell division
-
- Consists of:
 - stratified squamous epithelium
- Functions:
 - resists physical damage
 - e.g. presence of melanin - pigmentation
 - decreases water movement
 - Loss via oils; gain via keratin
 - prevents penetration by microbes
-
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43 ☐ **The Dermis**

- Basics
 - forms a deeper skin layer
-
- Composed of:
 - dense connective tissue = elastin & collagen
 - hair follicles, oil and sweat glands, muscle cells, nerves, sensory receptors, and blood vessels.
-
- Function:
 - collects sensory information
 - synthesizes vitamin D
 - helps regulate body temperature.
-
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44 ☐ **The integumentary system is more than just skin**

- Hair
 - important component of the integumentary system of mammals
 - helps to insulate their bodies
 - consists of a shaft of keratin-filled dead cells
-
- Oil (sebaceous) glands release oils that:
 - are associated with hair follicles
 - lubricate hair
 - condition surrounding skin
 - inhibit the growth of bacteria

45 ☐ **The integumentary system protects the body**

- Exposure of the skin to ultraviolet light

-
- causes skin cells to release melanin, which contributes to a visible tan
-
- damages DNA of skin cells, which can lead to:
 - premature aging of the skin,
 - Cataracts
 - Abnormal cell growth → skin cancers.
-

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THINKING ABOUT THE SKIN...HAVE YOU EVER WONDERED WHAT A PIMPLE ACTUALLY IS???

47 ☐ **What about skin blemishes?**
How do they relate?

- Acne results when the hair follicles that produce oil become clogged with dead cells and oil.
- When the pore is plugged, bacteria of the species *Propionibacterium acnes* (*P. acnes*) become trapped in the follicle.
- If the follicle ruptures into the dermis and white blood cells are recruited from the immune system, the pore is said to be inflamed in what we commonly call a "pimple" or "zit."

48 ☐ **Figure 20.12a**49 ☐

EXTERNAL EXCHANGE AND
 INTERNAL REGULATION

50 ☐ **Structural adaptations enhance exchange with the environment**

- None of these systems work without internal and external influences.
- Every organism is an open system that must exchange matter and energy with its surroundings.
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- Cells in small and flat animals can exchange materials directly with the environment.
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51 ☐ **What happens as organisms increase in size?**

- The surface area:
 - too small for the corresponding volume
 - too far away from the deepest cells of the body.
- In these larger organisms, evolutionary adaptations:
 - consist of extensively branched or folded surfaces, which increase the surface area
 - provide for sufficient environmental exchange.

52 ☐ **What are your organ systems actually doing?**

- Animals must exchange materials with the environment
 - The respiratory system = exchanges gases
 - The digestive system = acquires food & eliminates wastes
 - The urinary system = eliminates metabolic waste
 - The circulatory system = distribution of gases, nutrients, and wastes throughout the body.

53 ☐ **Indirect exchange between the environment and the cells of a complex animal**

54 ☐ **Animals regulate their internal environment**

- External environmental conditions may fluctuate wildly.
- Homeostatic mechanisms regulate internal conditions.

55 ☐ **Homeostasis depends on negative feedback**

- Homeostatic Control Systems
 - detect change & direct responses
 - Stimulus → Sensor → Control → Effector
 -
- Negative-feedback
 - Regulatory mechanism in which a stimulus causes an opposite output in order to maintain an ideal level of whatever is being regulated
 - keep internal variables steady
 - permit only small fluctuations around set points.

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58 ☐ **You should now be able to...**

- Explain why evolution does not lead to perfection.
- Describe the levels of organization in an animal's body.
- Describe the four main types of animal tissues. Note their structures and their functions.
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- Explain how the structure of organs is based on the cooperative interactions of tissues.

59 ☐ **You should now be able to...**

- Explain how artificial tissues and organs are being created in laboratories.
-
- Explain how organ systems work together to perform life's functions.
- Describe the general structures and functions of the 12 major vertebrate organ systems.
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- Relate the structure of the skin to its functions.

60 ☐ **You should now be able to...**

- Describe the components of well-designed scientific studies.
-
- Describe the systems that help an animal exchange materials with its environment.
-
- Define the concept of homeostasis and illustrate it with examples.
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- Explain how negative feedback is used to regulate internal body temperature.