

Integumentary systems

The integument is an animal's outer covering, and it functions in several unique roles:

- Prevention of mechanical injury
- Prevention of chemical injury
- Regulation of body temperature
- Excretion of wastes
- Reception of stimuli
- Exchange of respiratory gases
- Etc.

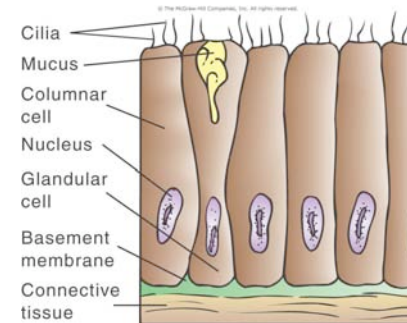
These functions have evolved in separate groups, but not all

Regardless of the “secondary” function of the integumentary system, the primary functions are *protection and control of exchanges* between the internal and external environments

Integumentary systems

Most invertebrates have a very simple integument:

- A single layer of columnar epithelial cells (the *epidermis*)
- These cells rest on a *basement membrane*
- A thin layer of connective tissue

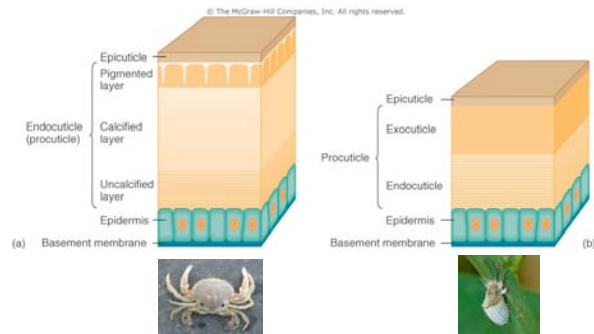


Integumentary systems

Cuticles are sometimes secreted by invertebrates as an added protective feature:

They can be thin and elastic (e.g. in rotifers)

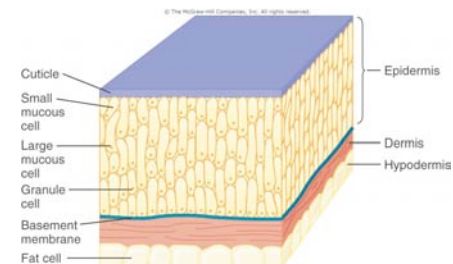
Or they can be thick and rigid, providing support to the body (i.e. exoskeleton)—can be problematic for growth (see earlier lecture)



Integumentary systems

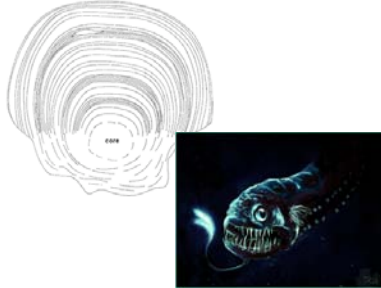
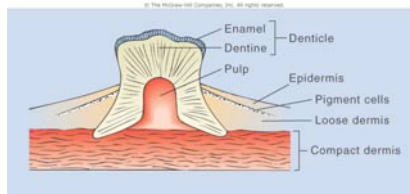
Vertebrate integument (= *skin*) contains an outer epidermal region as well as a connective tissue meshwork (*dermis*). A *hypodermis* is found below the skin, containing more connective tissue, adipose tissue, and nerve endings.

The skin of jawless fishes have ‘simple’ skin; they produce a significant amount of mucous slime to protect the animals from parasites



Integumentary systems

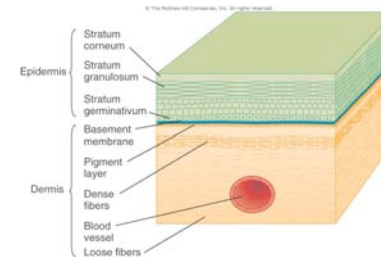
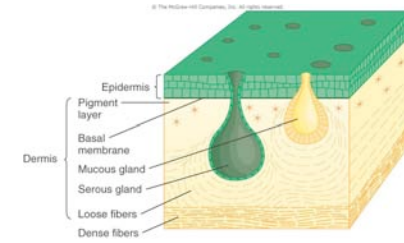
The skin of cartilaginous fishes contains small **placoid scales** (made of bone) called **denticles**; denticles are similar to vertebrate teeth. Once they reach maturity, they do not grow and are lost as they are worn down. They give the surface of the skin a sandpaper texture.



Bony fish have scales made of dermal bone. As the fish grows, scales grow at the margins and over the lower surface. The skin is permeable and functions in gas exchange. Mucus is also secreted to help prevent bacterial infections as well as to reduce friction as the fish swims. Other adaptations may be present (i.e. photophores in deep sea-dwelling species)

Integumentary systems

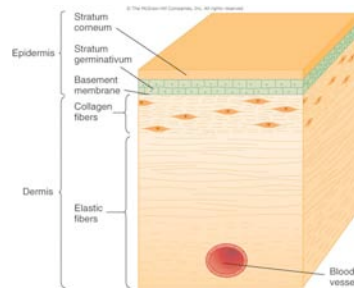
Amphibians have a thick epidermis, mucous cells, serous cells, and pigmentation cells. Keratin in the outer layers of the epidermis protect from desiccation and UV radiation; mucus produced also guards against desiccation and makes body slimy. Sensory structures and poison glands may also be present.



Reptiles have a very thick epidermis, and it is modified into cornified scales, scutes, turtle beaks, rattles, claws, or spiny crests. Keratinized layer resists desiccation and abrasion. As most reptiles grow, the skin is shed or molted.

Integumentary systems

Bird skin is very similar to reptilian skin: no epidermal glands are present (except the uropygial gland), epidermis is thin. Most prominent feature are the feathers.



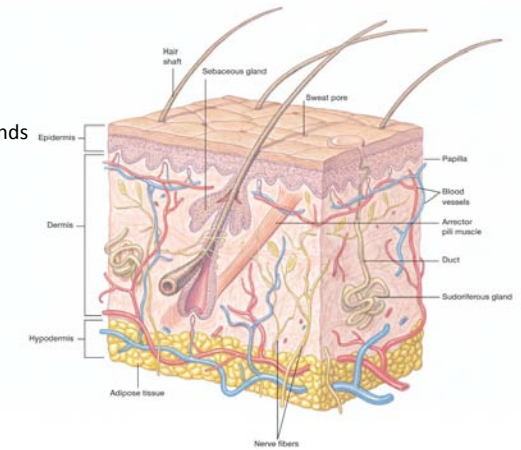
Integumentary systems

Mammalian skin tends to be characterized by:

- hair
- a large variety of epidermal glands
- stratified, cornified epidermis
- a thick dermis

There are many mammalian features that are derivatives of the epidermis:

- Hair
- Nails
- Claws and hooves
- Horns
- Baleen plates



Support systems

Animals utilize one of 3 basic types of support systems:

- **Hydrostatic skeletons:** a core of liquid (water or body fluid) surrounded by a sheath of tension-resistant muscle cells.
- **Exoskeletons:** provide locomotor functions (site for muscle attachment/pulling) as well as support and protection.
- **Endoskeletons:** enclosed by body tissues

The type of skeleton an animal possesses is primarily determined by its **body size**. For example, small animals can thrive with a hydrostatic skeleton, but past a certain point, the muscles required to 'control' a huge tube water would not be possible, requiring another form of support.

Support systems

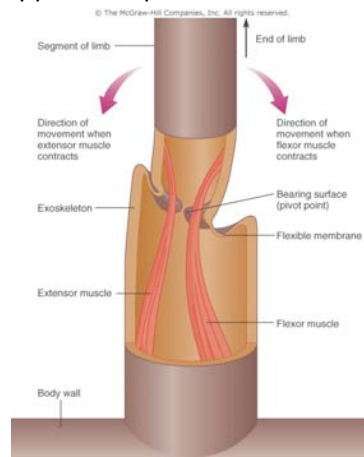
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- **Exoskeletons:** provide locomotor functions (site for muscle attachment/pulling) as well as support and protection.

Occurs in many groups; typically very hard, providing 'armor' that protects the animal. Also a major advance in the colonization of land, because it prevents the animal from drying out.

At joints in the exoskeleton, the cuticle thins out, allowing for movement. Some joints contain a very elastic protein called **Resilin** that acts like a rubber band in its ability to store energy and release (critical in the evolution of flight and jumping in insects)

Problem: exoskeletons make growth difficult!



Support systems

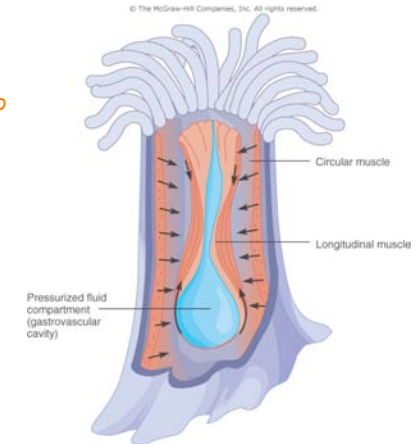
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- **Hydrostatic skeletons:** a core of liquid (water or body fluid) surrounded by a sheath of tension-resistant muscle cells.

Fluids are **deformable, but not compressible**. When **longitudinal and circular muscles** contract on the fluid compartment, the force is **transferred into movement**.

The fluid compartment can take many forms:

- gastrovascular cavity in acoelomates
- pseudocoelom
- coelom
- hemocoel



Support systems

Animals utilize one of 3 basic types of support systems:

- **Endoskeletons:** enclosed by body tissue

Endoskeletons of sponges consist of **spicules and spongin fibers** that keep the body (sometimes quite large) from collapsing.

Echinoderms have endoskeletons have small plates called **ossicles** surrounded by soft tissue.

The most familiar endoskeletons are those in vertebrates...

Vertebrate skeletal systems

There are two main types of support tissue in vertebrate skeletal systems:

- *cartilage*
- *bone*

Cartilage provides support, a point for muscle attachment, and transmits the force of muscular movement from one part of the body to another during contraction

Bone is significantly more rigid than cartilage because of the presence of calcified inorganic salts, but also provides storage of excess calcium, storage of adipose (fat) tissue, and a site for the manufacture of blood cells

Animals muscles and movement

Muscles are the power behind the movement of most animals. Several important properties:

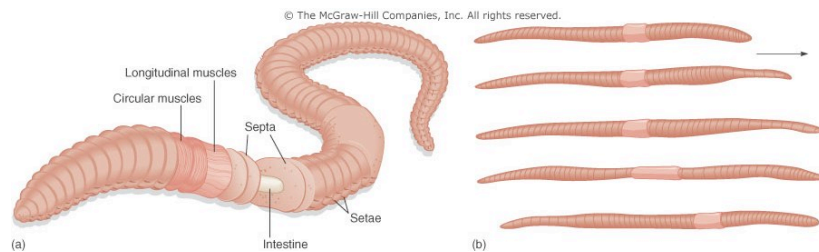
- contractility
- excitability (irritability)
- extensibility (stretchability)
- elasticity

We'll discuss the types of muscle tissue later, but almost all animals' muscles respond to *stimuli from the nervous system...*

Animals muscles and movement

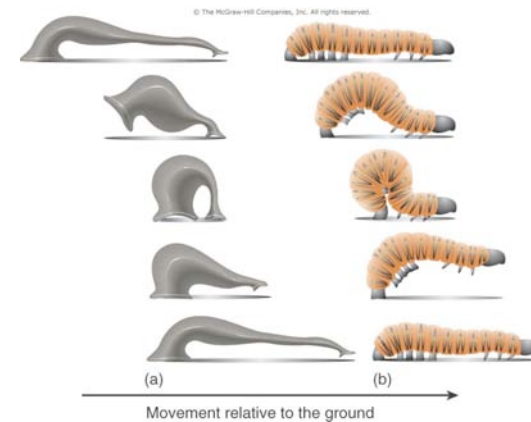
Soft-bodied invertebrates move the best over a firm substrate (they need something to "push" against); they move in **waves of muscular activity that is applied to the substrate** (= *pedal locomotion*).

This is more pronounced in large flatworms and segmented worms, when **circular and longitudinal muscles generate peristaltic waves**, enhancing locomotor abilities:



Animals muscles and movement

Leeches and insect larvae move "inch-worm" style—via a process called **looping**. Leeches have anterior and posterior suckers that provide alternating, temporary, points of attachment. Arching movements are due to contraction of longitudinal muscles:



Animals muscles and movement

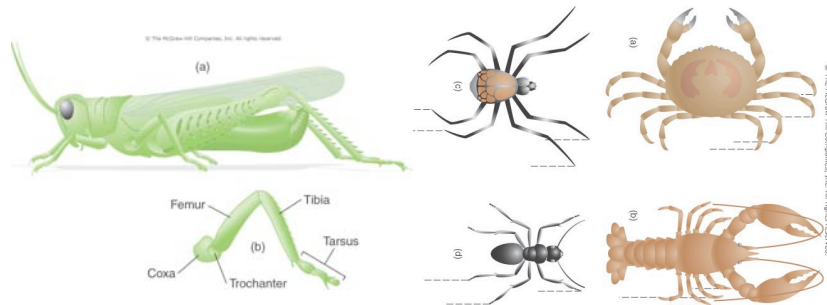
Walking requires more structural support than crawling or looping:

Rigid skeletal elements

Flexible joints

Tendons, muscles

In invertebrates, the limbs are uniform in structure and the body is carried, "slung" between the sets of limbs. Walking does not involve raising or lowering the body; most arthropods walk forward, but crabs tend to walk in a sideways manner.

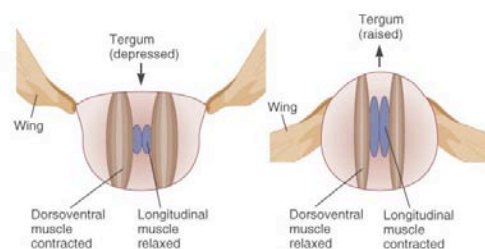


Animals muscles and movement

Insects were the first animal to fly, and it undoubtedly contributed to their massive success on earth.

There are two mechanisms of flight in insects: **direct (synchronous)** and **indirect (asynchronous)**.

Indirect flight involves dorsoventral muscles producing an *upward thrust*. The *downward thrust* results from longitudinal muscles contracting, causing the exoskeleton to arch upward. With every wingbeat, energy is 'stored' in the exoskeleton, enhancing the power and velocity of each wingbeat.

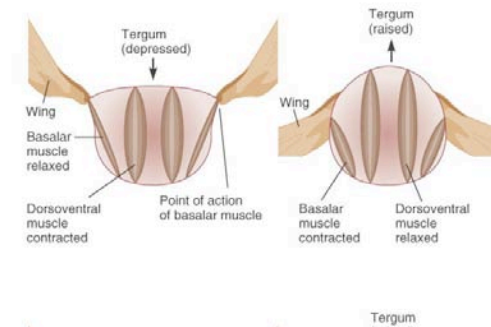


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Direct flight involves muscles acting on the base of the wings, contracting to produce a *downward thrust*. Muscles attached dorsally and ventrally on the exoskeleton produce the *upward thrust*. Direct flight mechanisms are dependent on nerve impulses that must precede each wingbeat:



Animals muscles and movement

Jumping (usually an escape response in invertebrates) is characterized by long legs. The problem is that more force than the weight of the body must be generated to lift the body off of the ground. Long legs increase the mechanical advantage of the levers, producing more force.

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