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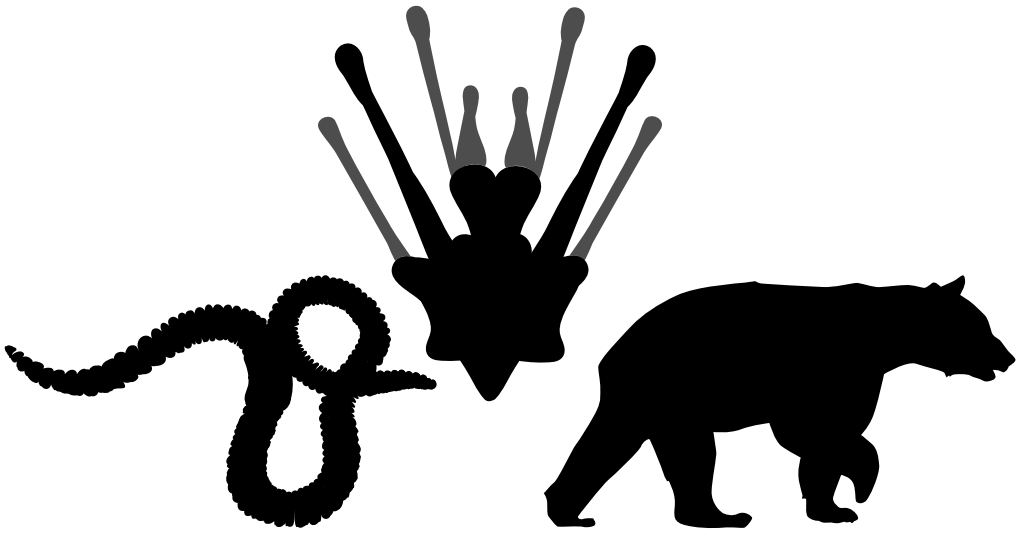
Body Systems:

Excretory, Reproductive, Nervous and Hormonal

Educators's Resource Guide



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Stop and Think

What do living things have in common? What separates living things, like plants and animals, from non-living things, like rocks and fire?

Living things share a set of features that make them different from non-living things. They are the **characteristics of life**[1].

- **Reproduction**: living things can reproduce their own kind, making **offspring** - like these grizzly bear cubs

Grizzly Bear, *Ursus arctos horribilis*
Mick Thompson - CC BY-NC 2.0

- **Energy Processing:** Anna's hummingbirds obtain fuel from the nectar of flowers, which is broken down in the body and used as energy for things like flight

Anna's Hummingbird, *Calypte anna*
Becky Matsubara - CC BY 2.0

- **Growth and Development**: information encoded in DNA controls patterns of growth and development - like when a Western toad transitions from an egg to a tadpole to an adult

Western Toad, *Anaxyrus boreas*
Jamie Clarke

- **Response to Environment**: a round-leaved sundew folds its sticky hairs to trap a damselfly in response to the stimulus of prey landing on its leaves

Round-leaved Sundew, *Drosera rotundifolia*
Bern Dupont - CC BY-SA 2.0

- **Regulation:** the regulation of blood flow in white-tailed jackrabbits' ears helps keep body temperature constant by exchanging heat with the environment

White-tailed Jackrabbit, *Lepus townsendii*
Tom Koerner - CC BY 2.0

- **Order**: living things have order and organization as shown in a close look at a patch of sea sandwort

Sea Sandwort, *Honckenya peploides*
Bas Kers - CC BY-NC-SA 2.0

- **Evolutionary Adaptation**: the giant Pacific octopus camouflages into its surroundings - an adaptation that makes it better suited to its environment and which evolved over many generations

Pacific Octopus, *Enteroctopus dofleini*
Cathleen Shattuck - CC BY-NC-ND 2.0

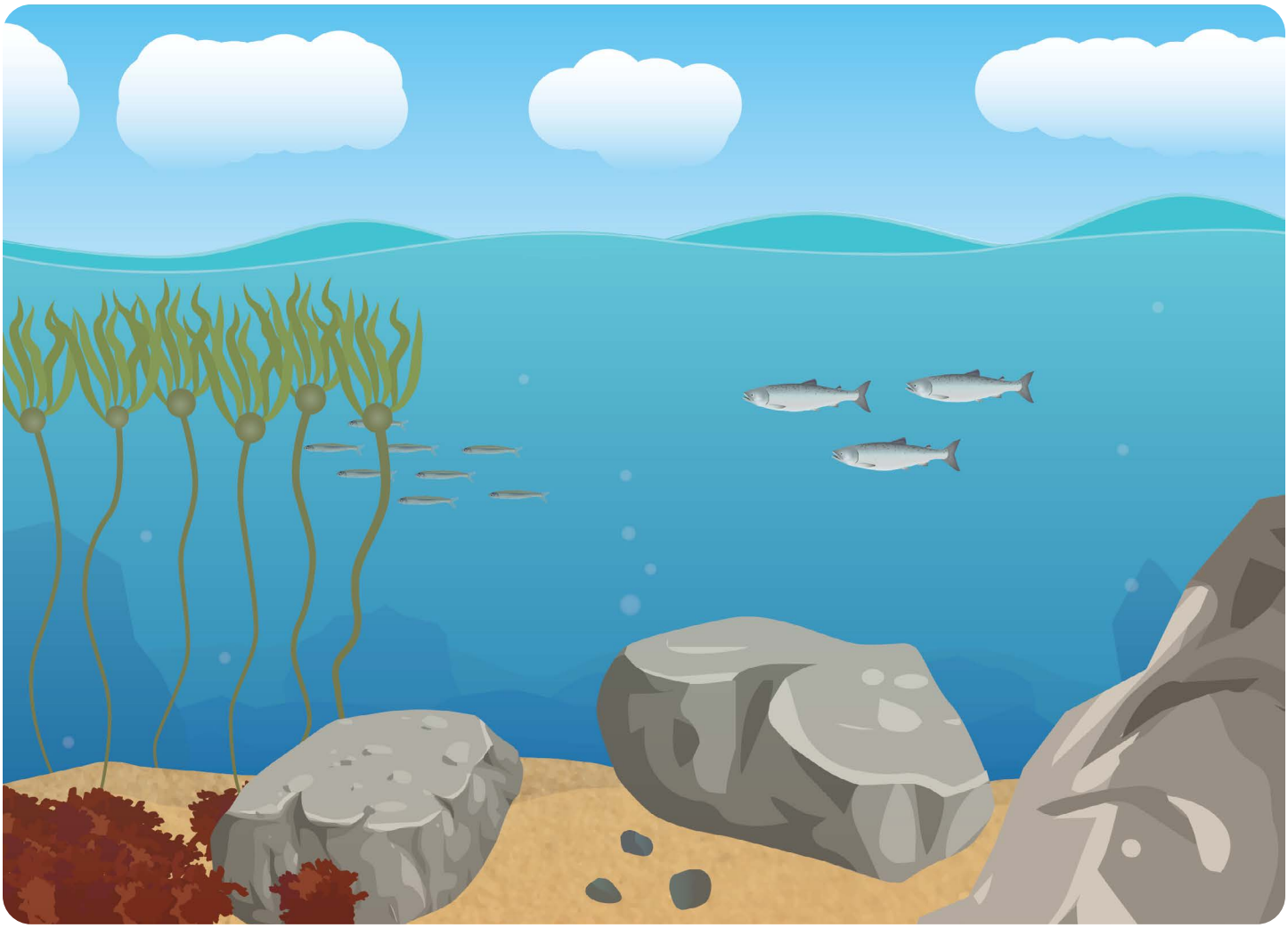
------- Stop and Think -------

A rocket ship needs fuel to move and is highly ordered and organized... Is a rocket ship a living thing?

While non-living things can have some of the characteristics of life, a living thing - an **organism** - can do all of these things. So while a rocket ship might use fuel to move and be highly ordered, it can't reproduce, grow or evolve; therefore, it isn't a living thing.

------- Class Activity -------

Take a look at the image below: name two living and two non-living things you can see, and explain why you classified those things as living or non-living.



Animals are a group of organisms that carry out the essential processes of life - like obtaining and processing energy, regulating the body, and responding to the environment - using specialized **cells**, **tissues** and **organs** which are grouped into **body systems**. Cells are the smallest, most basic units of living things.[2] Tissues are groups of cells with a shared form and purpose. Organs are groups of tissues that work together to do something specific - the heart, for example, is an organ that pumps blood around the body.[3] And body systems are groups of organs that, all together, perform a function, like digestion or reproduction.[3]

First, we'll name the body systems and describe their functions in people. Then, we'll take a closer look at the body systems of organisms across the animal kingdom.

Body systems and their functions in humans

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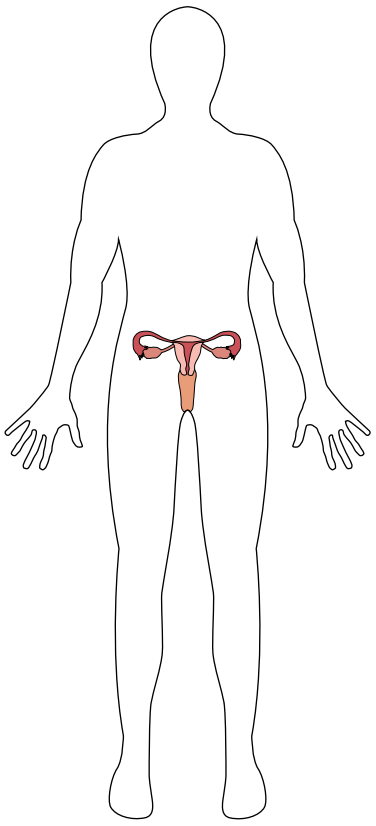
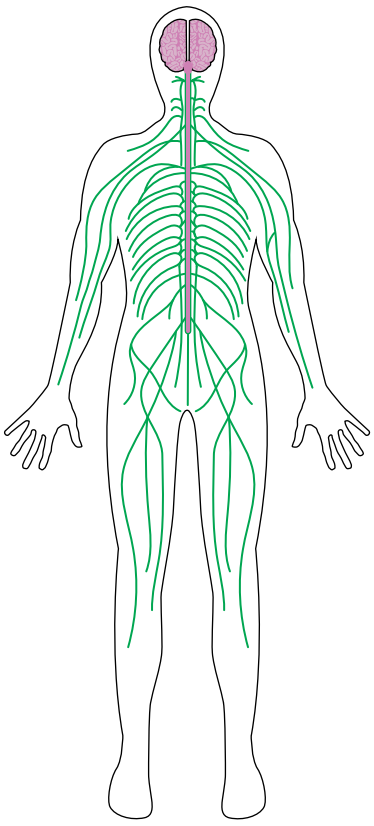
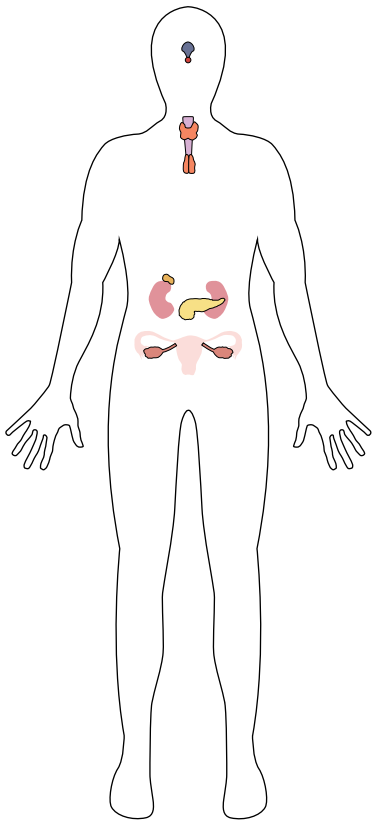


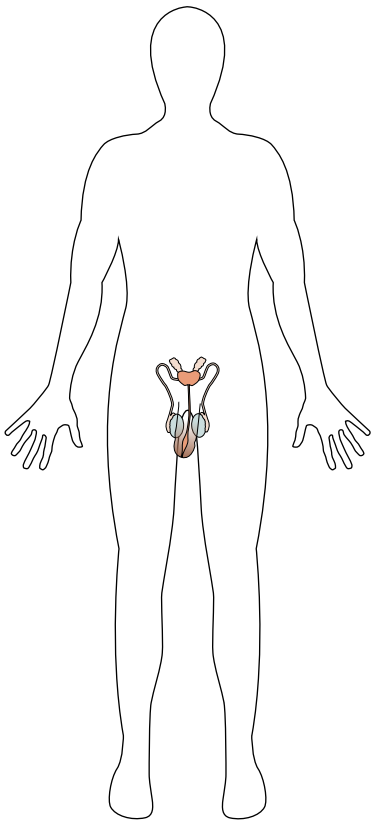
Female Reproductive



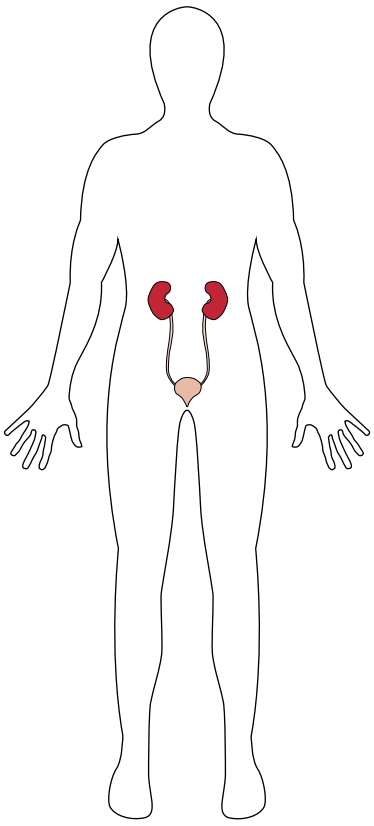
Nervous



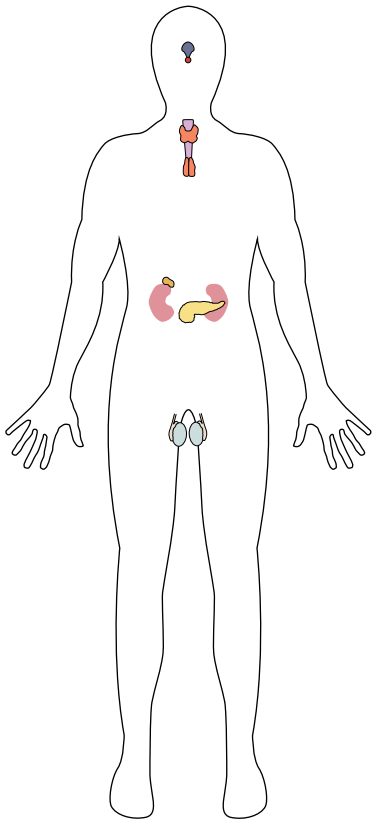
Female Hormonal



Male Reproductive



Excretory



Male Hormonal

Body systems and their functions in humans[3,4]

- **Respiratory System**: oxygen and carbon dioxide (gas) exchange
- **Circulatory System**: transports gases, nutrients, wastes, hormones and other substance throughout the body
- **Digestive System**: breaks down food and absorbs nutrients into the body
- **Musculoskeletal System:** supports, protects and moves the body
    - **Skeleton:** system of support and movement, protects the internal organs, stores minerals, blood formation
    - **Muscles:** movement and heat production
- **Excretory System:** eliminates wastes (urine), regulates blood pH (how acidic/basic?) and volume
- **Reproductive System:** produces sex cells (sperm or eggs), either transfers and deposits sperm or provides an environment and resources for fertilized egg to grow and develop
- **Nervous System:** responds to stimulus and sensations, coordinates the activities of the other body systems
- **Hormonal System:** regulates body functions using chemicals called hormones

------- Stop and Think -------

What are examples of organs that belong to these body systems?

Body systems in different animal groups

The body systems of some animals are very similar in structure and organization to our own - but some animals look and live very differently than we do. Starting with animals that are most closely related to us and moving towards increasingly distantly-related groups, let's compare body systems throughout the animal kingdom.

Stop and Think

Fill in the table below as you go through the next pages: which cells/tissues/organs are a part of the body systems of each of the animal groups? Do you notice any trends or patterns?

	Excretory	Reproductive	Nervous	Hormonal
Mammals				
Birds				
Fish				
Echinoderms				
Insects				
Trematodes				
Sponges				

Mammals

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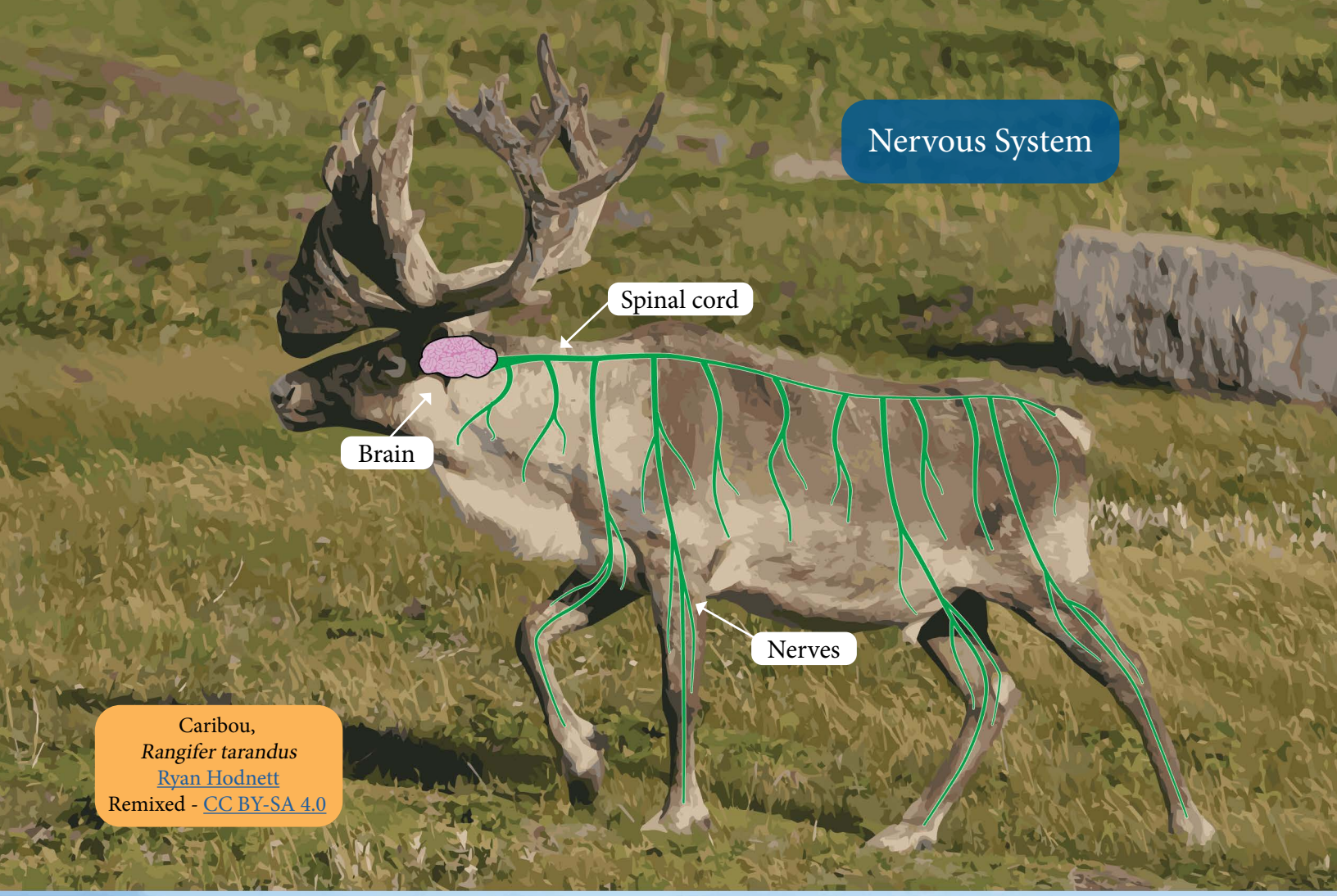

Caribou,
Rangifer tarandus
Ryan Hodnett
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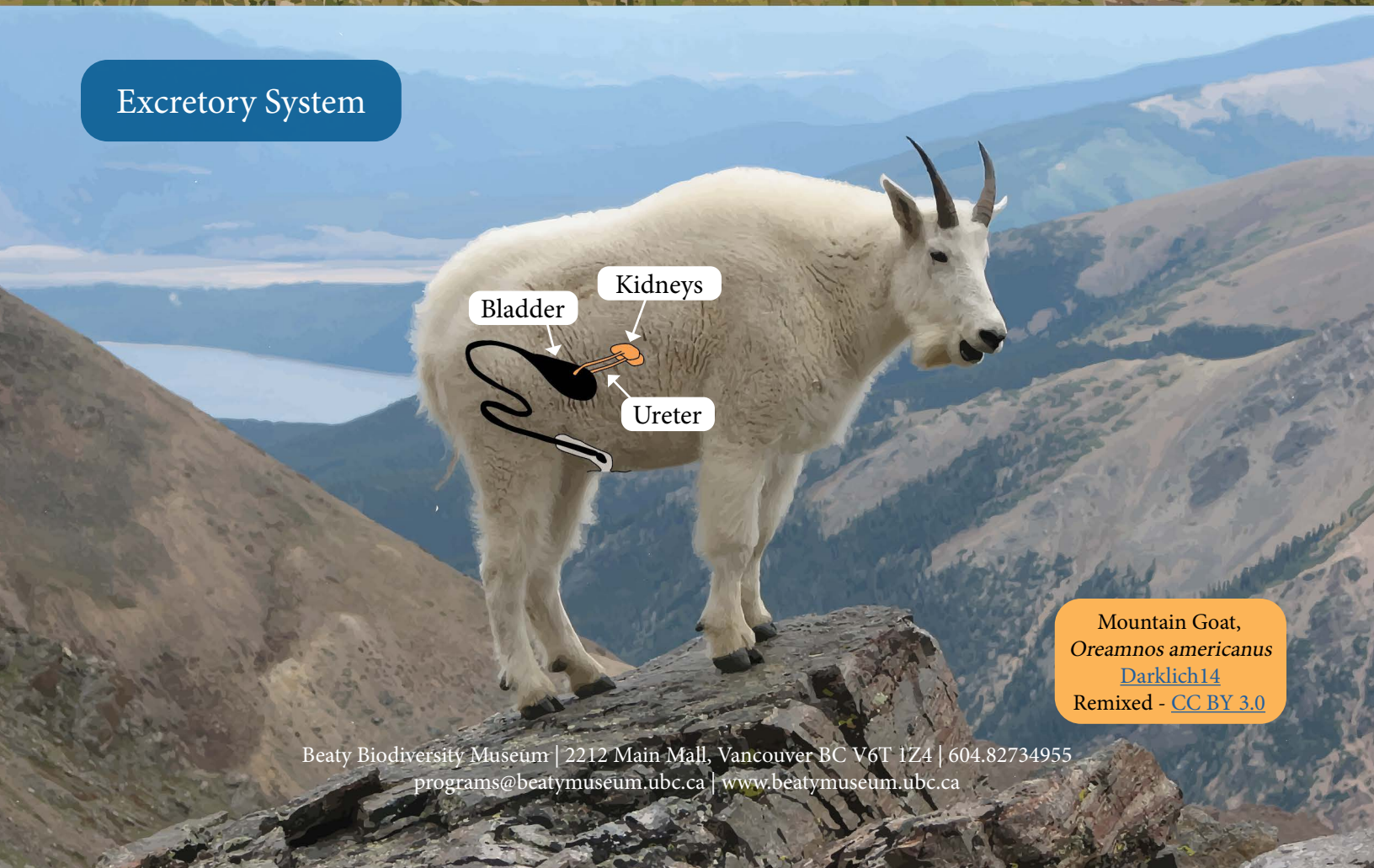

Mountain Goat,
Oreamnos americanus
Darklich14
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Mammals[5,6,7,8,9,10]

Mammals are warm-blooded animals with four limbs and hair that produce milk to feed their young. Many familiar creatures belong to this group: kangaroos, mice, bears, elephants, whales, monkeys, and platypuses are all mammals… And humans are, too! Because humans are mammals, our body systems tend to be similar to those of other animals in this group.

Excretory: Mammals have **kidneys** that filter out wastes from the blood. Water, ions and small molecules are removed by the **renal corpuscle**. Some of these materials are useful, and so are separated out and reabsorbed into the body. Waste materials and water are drained into tubes called **ureters** and collect in the **bladder** before being excreted as urine. Mammals that live in hot, dry environments reabsorb much of the water that is removed by the renal corpuscle and excrete a very concentrated urine.

Reproductive: The male mammalian reproductive system is made up of the **testes**, a few different glands and the **penis**. The testes are the site of sperm production; they are held in a pouch called the **scrotum**. Males produce sperm continuously from the time they reach sexual maturity onward. Depending on the species and whether or not it is mating season, the penis and testes may be housed inside or outside of the body. Several different glands - the **bulbourethral**, **prostate** and **vesicular glands** - produce substances which are added to the sperm to make semen (which gives sperm energy and something to swim in). During mating, semen passes through the erect penis.

The female reproductive system of **placental mammals** - like monkeys, rabbits and whales - is made up of the **ovaries**, the **uterus** and the **vagina**. These reproductive parts are all held within the body. The ovaries are the site of egg production. Unlike male mammals, which produce sperm throughout their lives, evidence suggests that female mammals are born with all of their eggs. The uterus is the place where an egg develops if it meets a sperm cell and is fertilized. The vagina is the site where semen is deposited during mating. It is also a part of the birth canal - the path that offspring take when they're born.

The fertilized eggs of **marsupials** - kangaroos, koalas, possums and relatives - do not attach and develop inside the mother's uterus like in placental mammals. Instead, incompletely-developed offspring pass out of the vagina and into their mother's pouch (**marsupium**) after staying in the uterus for only 8 to 40 days. Offspring are carried around in the pouch for several weeks or months, where they continue developing and feed on their mother's milk.

Monotremes are a small group of egg-laying mammals. They include the echidnas and the platypus. Unlike placental mammals and marsupials, which give birth to live offspring, female monotremes lay yolky, shelled eggs out of which their young hatch.

Nervous: The nervous system of vertebrates can be broken down into two parts: the central nervous system, which includes the **brain** and **spinal cord**; and the peripheral nervous system, which includes the nerves in the head and body, the nerves that control unconscious body functions like the beating of the heart, and the sense organs that see, hear, taste, feel and smell the environment.

The brain is the "command centre" where information is processed and stored. The **cerebrum** is a region of the brain that is associated with intelligence; in mammals, it is very large. The outer portion of the cerebrum, called the **cerebral cortex**, is enlarged as well, and often highly folded - another indicator of intelligence. The spinal cord is an information "highway" connecting the brain and body.

Most mammals have complex, colour-detecting and image-forming **eyes** to see; moveable, external **ears** that direct sound to the **eardrums**; external **nares** (nostrils) lined with tissue that processes smell; **taste receptor cells** (tastebuds) in the mouth and throat; and nerves in the skin to feel.

Hormonal: The hormonal system is made up of **glands** that produce and release chemical messengers - hormones. Hormones stay inside the body and travel through the blood. Hormone-producing glands are separate but work together. Some of these glands are in the brain, while others are located in other parts of the body, including the testes and ovaries. The hormonal system works to regulate growth, reproduction, responses to stress and many other things.

Birds

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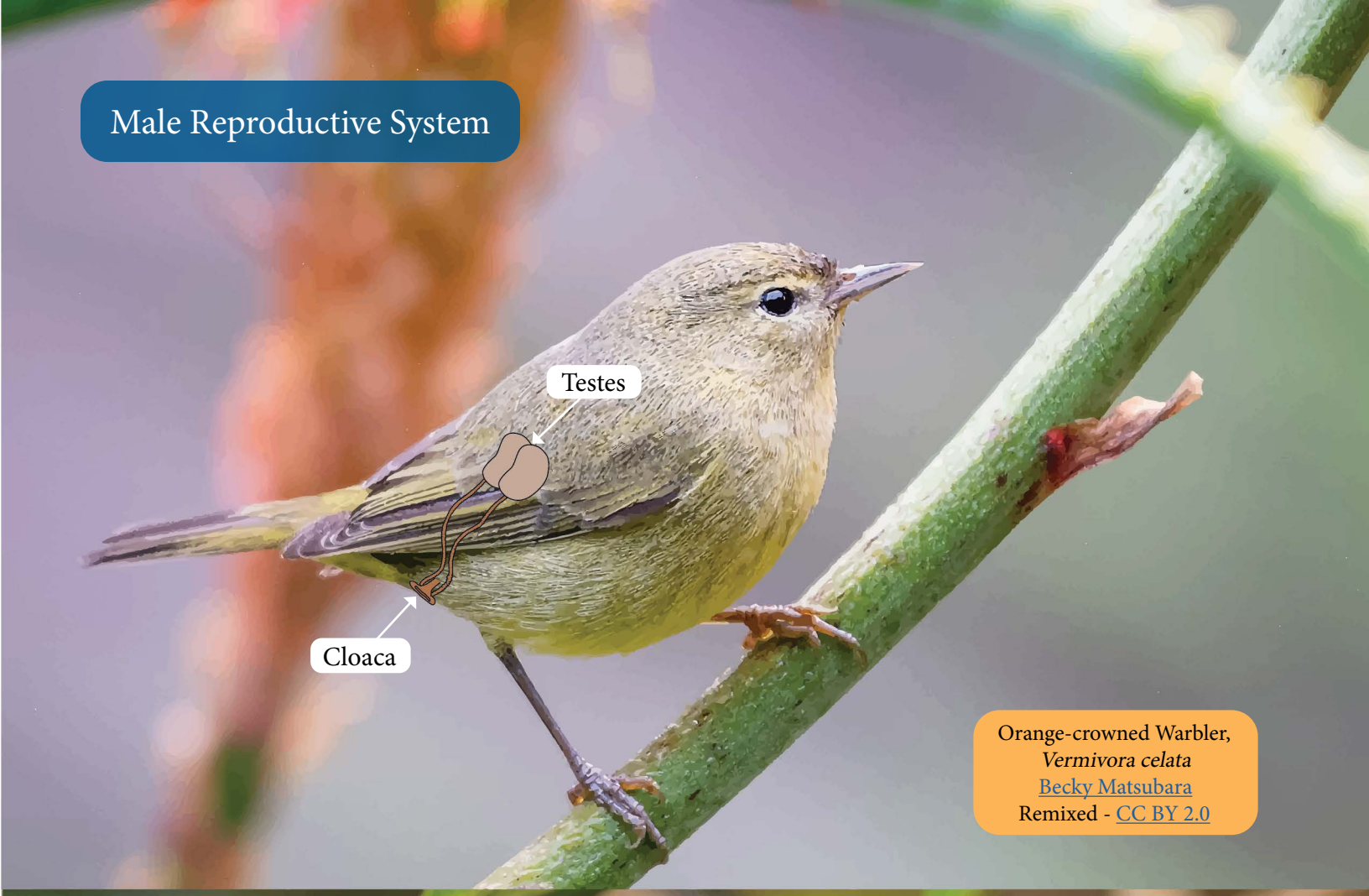
Male Reproductive System



Orange-crowned Warbler,
Vermivora celata
Becky Matsubara
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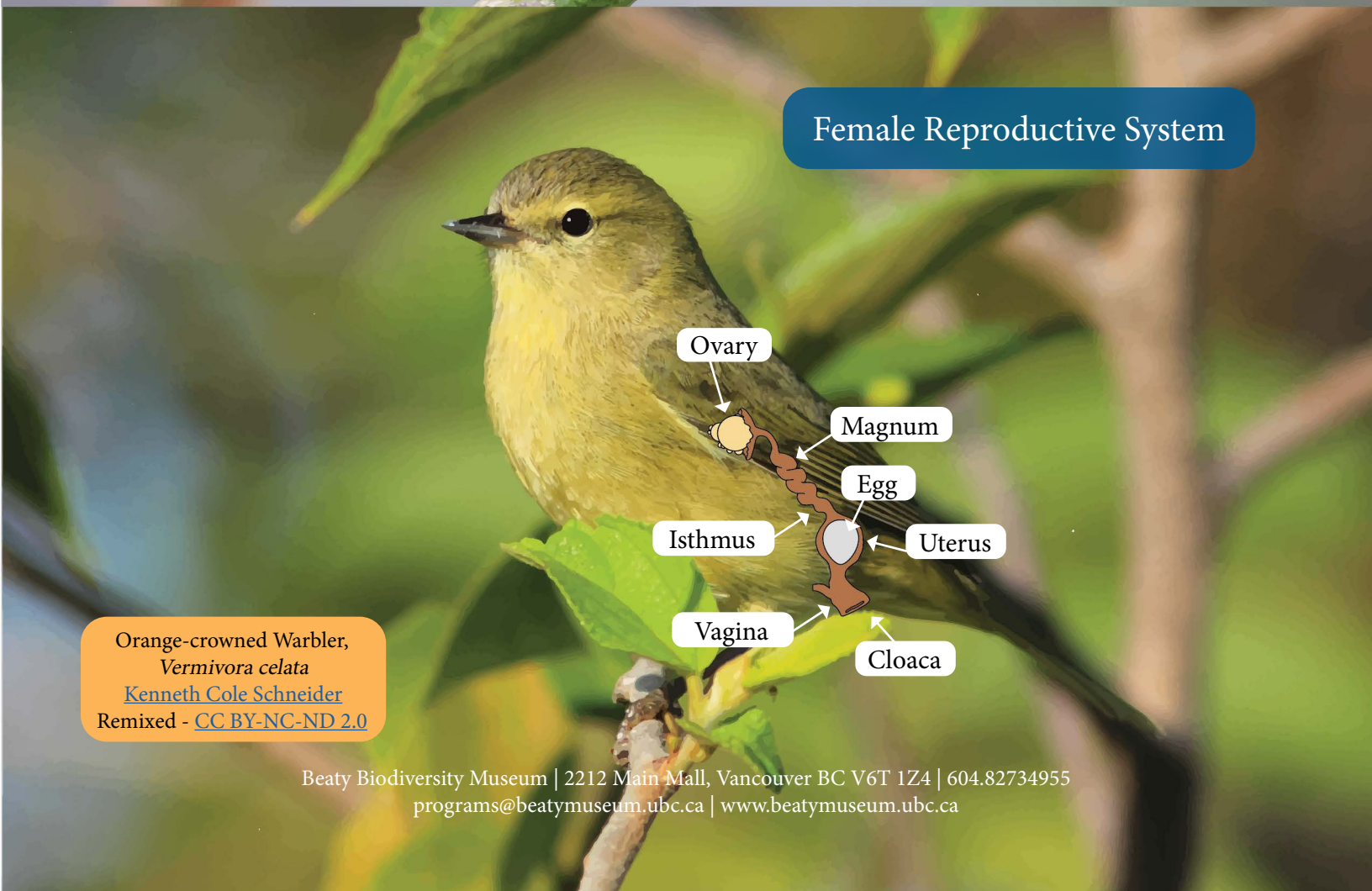
Female Reproductive System



Orange-crowned Warbler,
Vermivora celata
Kenneth Cole Schneider
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Birds[5,7,11,12,13,14,15,16,17,18,19,20,21]

Did you know that birds are actually small dinosaurs? This group of animals is winged, feathered and specialized for life in the air (and the water, and on land). Flight is a very energetically demanding way of moving about - so birds' bodies are specially adapted to deal with these demands.

Excretory: The **kidneys** are the main organ of the excretory system. They filter water and substances out of the blood. As in mammals, many of the materials the kidneys remove from the blood are useful - so they are reabsorbed back into the body. The water and wastes the body doesn't need travel from the kidneys, through tubes called **ureters** and to the **cloaca** - the main space and opening where the excretory, digestive and reproductive systems meet and exit. In the cloaca, excretory products like uric acid or guanine (instead of urine) are eliminated at the same time as undigested material (poop) from the digestive system.

Reproductive: Male birds produce sperm in the **testes**. During mating, sperm travels from the testes, through tubes and into the cloaca. Most birds mate by coming together for a "cloacal kiss," during which sperm is transferred from the male to the female's cloaca. Some male birds, however, develop a **penis** to transfer sperm to a mate.

Female birds produce eggs in the **ovary**. Attached to the eggs are yolk sacs. Only the left ovary develops in most birds - the right ovary is present but doesn't fully develop. Part of the tube that connects the ovary to the **uterus**, called the **magnum**, produces the albumen - the egg white - that surrounds the egg and yolk. The part of the tube below the magnum is the **isthmus**. The isthmus adds layers around the egg yolk and white. The uterus is also known as the **shell gland** in birds. As its name suggests, it adds the thin, hard external shell to the egg. The colours and patterns of some eggs are also added in the shell gland. Finally, the shelled egg is held in the **vagina** before it is laid.

The ovaries and testes of birds enlarge only during the mating season. For the rest of the year, they shrink down to reduce the weight of the body.

Nervous: Like other vertebrates, birds have a nervous system composed of a **brain**, a **spinal cord**, nerves and sensory organs. The **cerebrum** - the region of the brain associated with intelligence - is enlarged in birds as well as mammals. Unlike mammals, birds don't have highly folded cerebral cortices; they do, however, have a large **dorsal ventricular ridge**, a region deep within the cerebrum that is also tied to animal intelligence.

Birds have a very strong sense of sight and sound. They tend to have large, powerful **eyes** to fly safely, find food and choose mates. Like mammals, birds can see colour and images; unlike most mammals, they can also see part of the UV spectrum of light. Although their **ears** lack the external components of mammalian ears, the funnel-shaped openings in the side of the head lead to very similar internal hearing structures. Birds also have **taste receptors** inside their mouths, although evidence suggests they have fewer than mammals like humans. Special tissue in the **nares** (nostrils) detects smells but the relative importance of smell in birds is not well known. Nerves in the skin transmit information about touch.

Hormonal: Birds produce hormones in many different glands - examples include the **pituitary gland**, the **adrenal gland** and the **parathyroid gland**. These hormones are involved in reproduction and egg-laying, migration, song, and many other functions.

Fish

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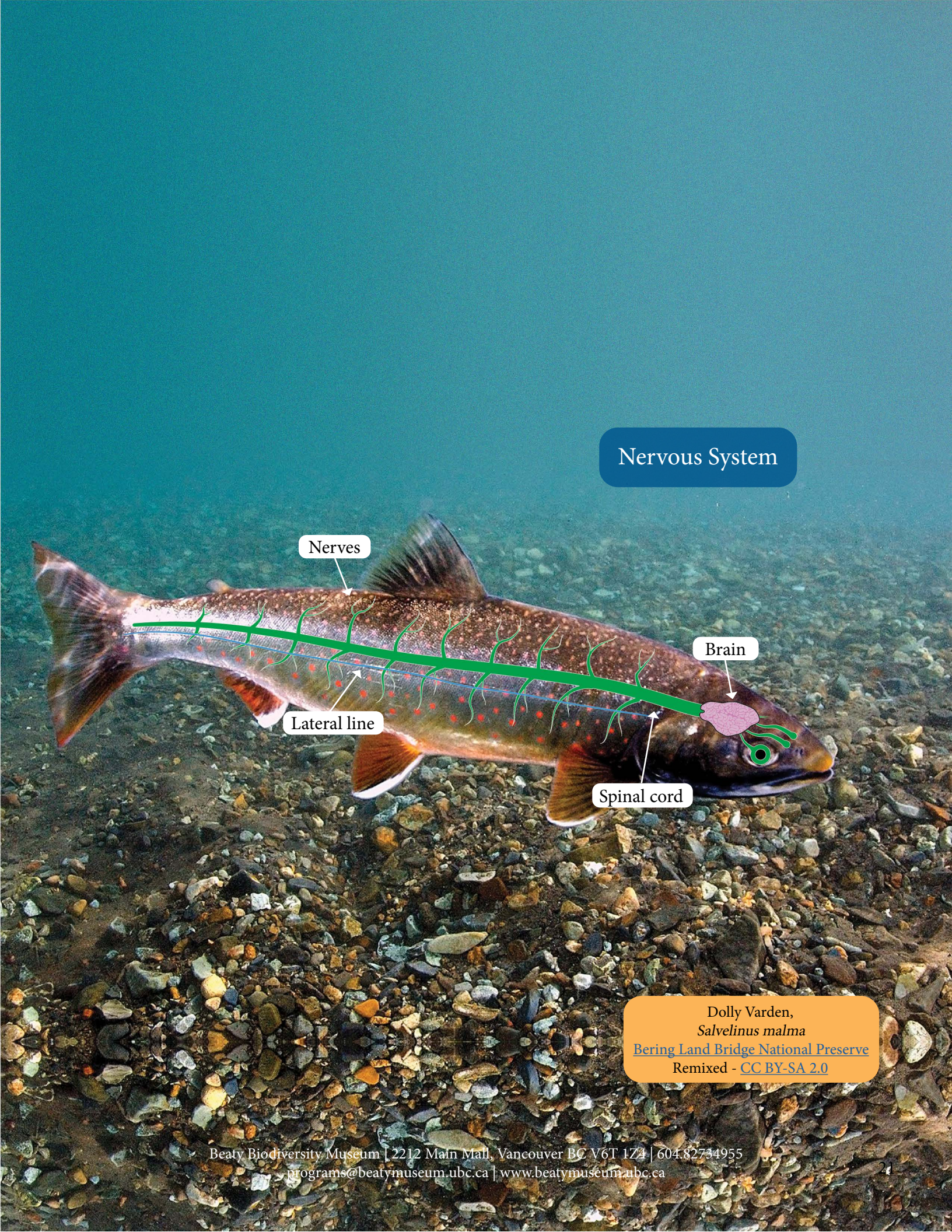
Nervous System



Dolly Varden,
Salvelinus malma
Bering Land Bridge National Preserve
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Fish[5,27,28,29,30,31]

Fish are scaly, finned, gill-breathing animals adapted to life underwater (with a few exceptions). They are the group of vertebrates most closely related to **invertebrates** - animals without a spine. They are also the group that gave rise to the four-legged vertebrates (**tetrapods**) like amphibians, birds and mammals.

Excretory: The excretory system of fish is quite similar to that of amphibians. Blood is filtered through the **kidneys** and wastes are collected. From there, they travel down a duct to the **cloaca** and are released from the body.

Reproductive: The main structures of the female reproductive system are the **ovaries** and the **oviducts**. The ovaries produce eggs. Depending on the type of fish, the ovaries may also hold young while they develop inside their mother's body. Oviducts connect the ovaries to the outside environment. The oviducts may simply provide a passage for the eggs, they may produce protective coverings for the eggs or they may hold young while they develop and grow inside their mother. Some fish don't have oviducts - the eggs of these species are shed from the ovary right into the body cavity, and released into the environment through openings called **genital pores**.

The male reproductive system is made up of the sperm-producing **testes** and ducts that connect them to the cloaca. The connective ducts may be shared with the excretory system or separate from it. Sperm are released through the cloaca for external fertilization. Some male fishes have **intromittent organs** - modified body parts that transfer sperm inside the bodies of their mates for internal fertilization.

Nervous: The **brain**, **spinal cord**, sensory organs and a network of nerves in the body make up the nervous system. Fish have a well-developed sense of smell. Two large **olfactory bulbs** at the front of the brain process information coming in through the **nares** (nostrils) about chemicals in the water. The **eyes** process images; most fish can see in colour. Fish also have internal **ears** that detect sound vibrations, and a **lateral line** - a series of small openings on the head and body - that senses movements in the water.

Hormonal: Fish have several hormone-producing **glands** spread throughout their brains and bodies. The hormones those glands produce are involved in growth, reproduction, responses to stress and environmental change…

Echinoderms

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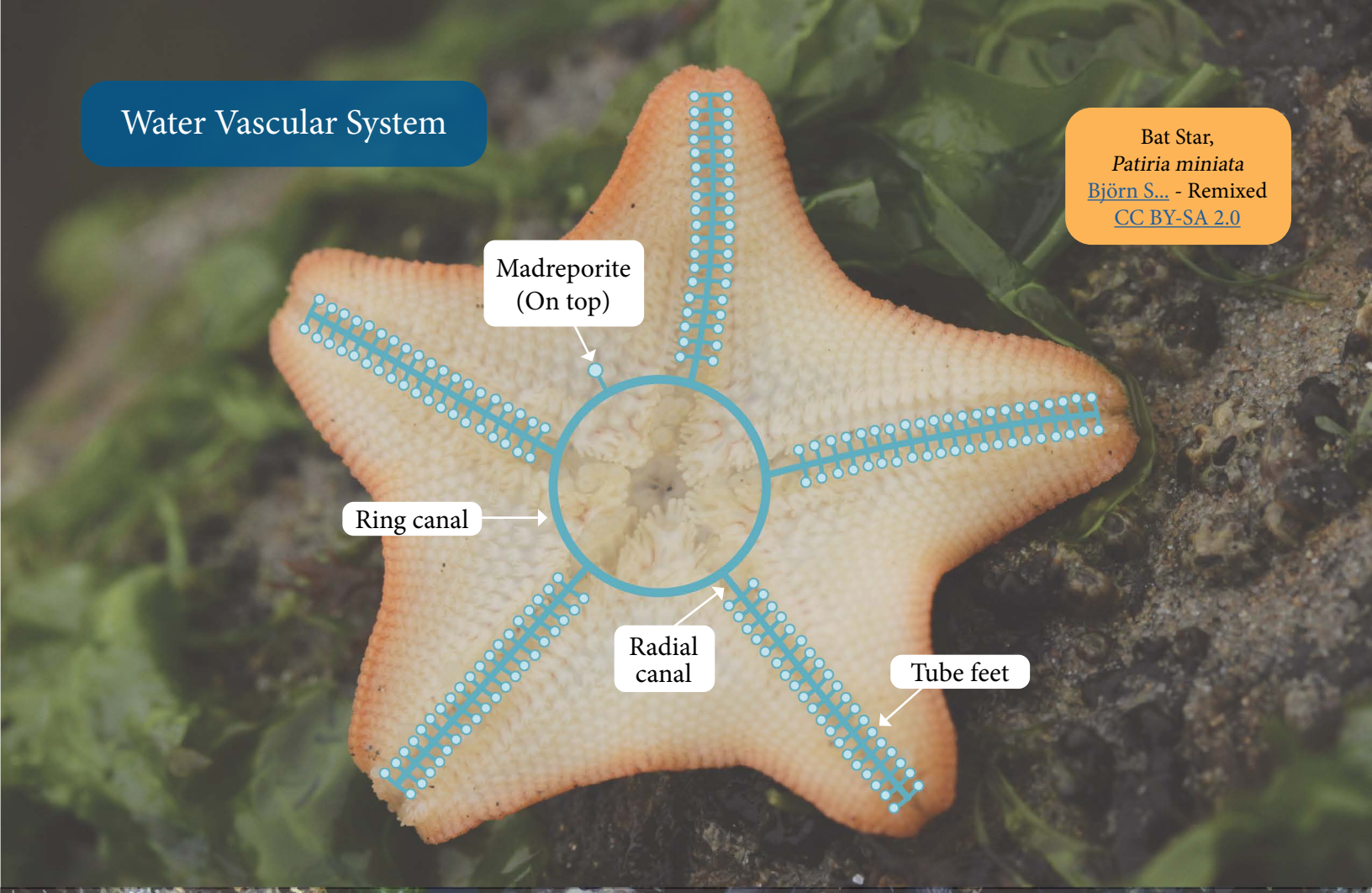

Bat Star,
Patiria miniata
Björn S... - Remixed
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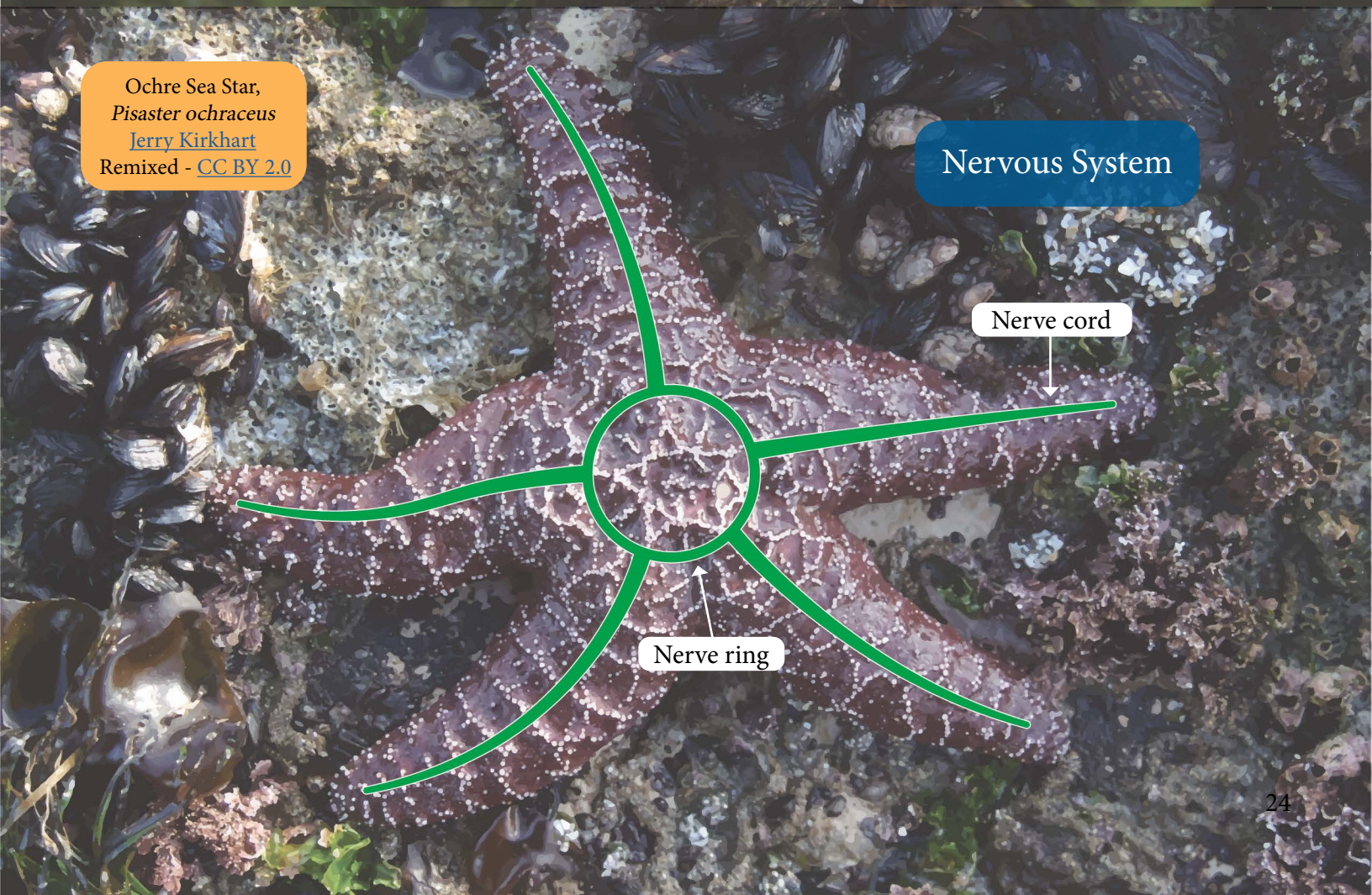

Ochre Sea Star,
Pisaster ochraceus
Jerry Kirkhart
Remixed - CC BY 2.0

Echinoderms[4,32,33,34]

While echinoderms like sea stars, sea urchins and sea cucumbers may not look much like you or me, they are actually some of our closest invertebrate relatives! All echinoderms live in the ocean - so their bodies are especially adapted to life underwater. One of the most important of these adaptations is the **water vascular system**: a series of internal tubes and tanks through which water is circulated. The water vascular system does many of the things our different body systems do using only the flow of water. It is unique to echinoderms and is particularly well-suited to a slow-moving life on the bottom of the sea.

Excretory: The rows of **tube feet** - leg-like feelers - on the body of an echinoderm are responsible for getting rid of wastes. Tube feet belong to the water vascular system and function in movement, respiration, circulation and feeding, as well as excretion. Wastes (urine) travel across the thin walls of the tube feet and into the water around them - no need for kidneys, ureters or bladders!

Reproductive: The majority of echinoderms are **dioecious** - individuals are either male or female and produce either sperm or eggs. There is quite a bit of variation in the echinoderm reproductive system. The main parts are the **gonads**, where sperm and eggs are produced, and ducts and openings that release sperm and eggs outside of the body. Typically, sperm and eggs are released into the water, where they meet, fuse and form offspring. Releasing sex cells into the open water to reproduce is called **broadcast spawning**. The release of eggs and sperm is synchronized in some species.

Nervous: The nervous system of an echinoderm is decentralized, meaning there is no command centre - in other words, no brain. Instead, a **nerve ring** circles around the middle of the body and **nerve cords** extend out into the arms. The tube feet function as sensory structures: they taste and smell the environment and pass that information to the nerves. Echinoderms can't hear or see.

Hormonal: In female echinoderms, hormones produced by the nerve cords bring about the development and release of eggs from the ovaries.

Insects

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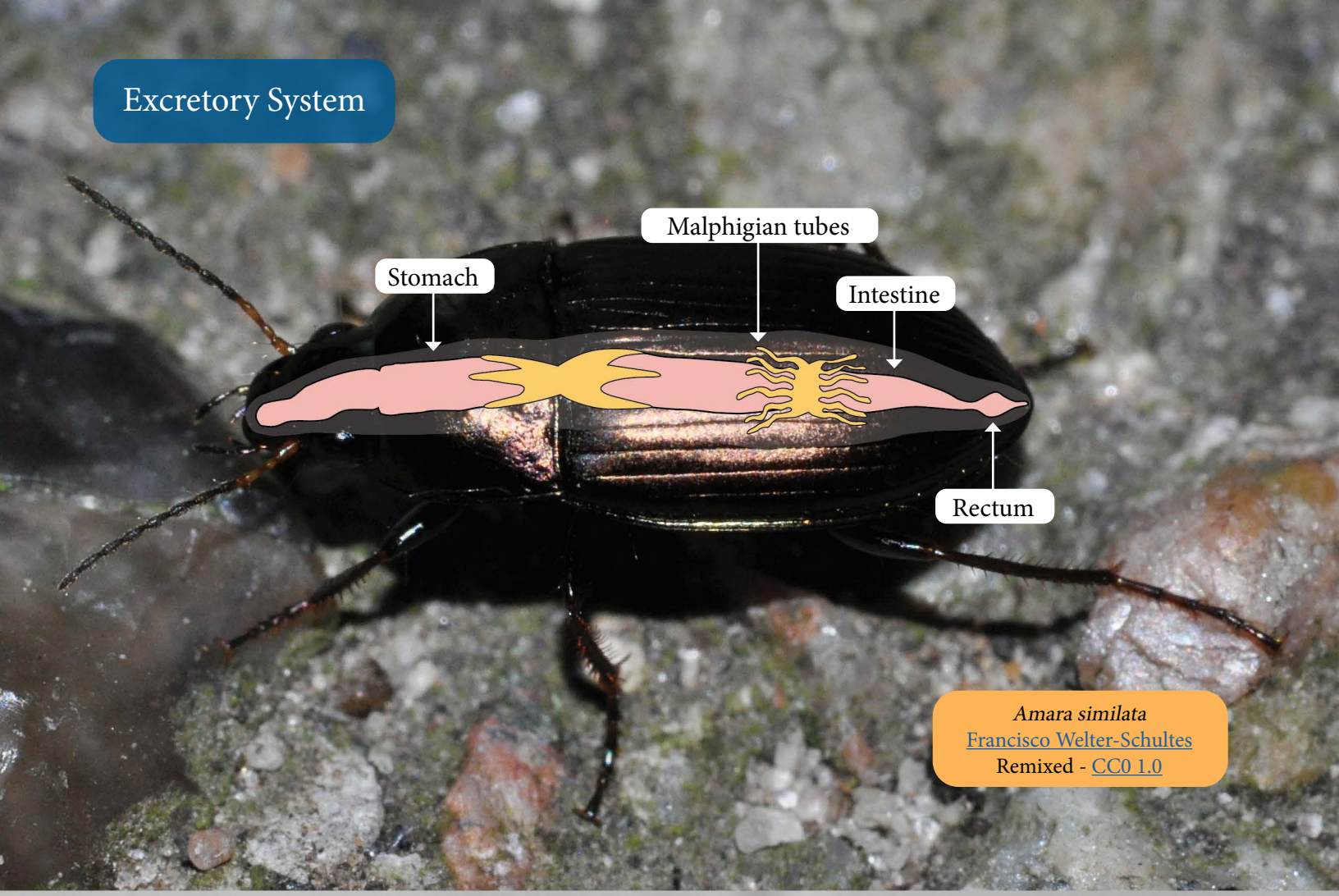
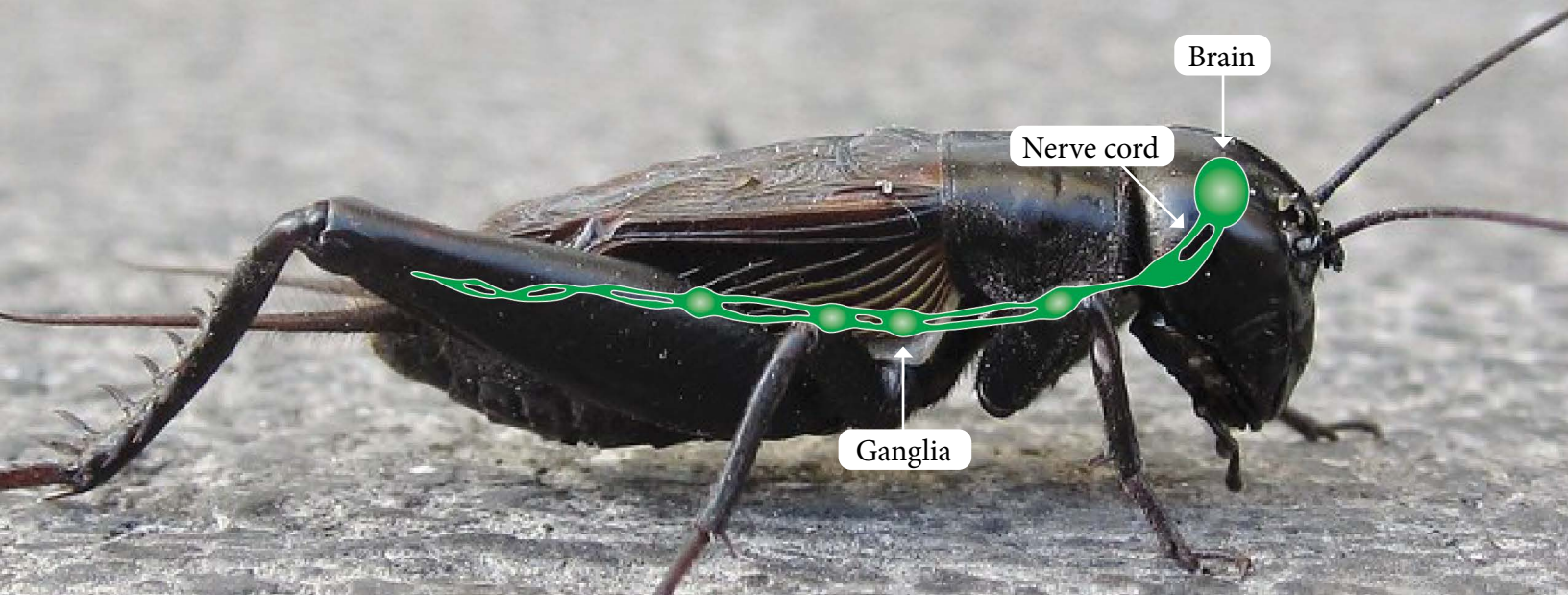
Excretory System



Amara similata
Francisco Welter-Schultes
Remixed - CC0 1.0

Fall Field Cricket,
Gryllus pennsylvanicus
Kurt Andreas
Remixed - CC BY-NC-SA 2.0

Nervous System



Insects[4,32,34,35,36,37]

Insects are amazingly diverse. Scientists have named about a million insect species, but estimate that millions more remain to be named and described! A few key characteristics unite this myriad of different species. Insects have a body composed of three segments - the head, thorax and abdomen; they have six legs (three pairs) attached to the thorax; they have four sets of head appendages - one pair of antennae and three pairs of "jaws"; and they share some respiratory and excretory structures that we'll get to later. Most insects, but not all, also have wings coming out of their thorax.

Excretory: One of the challenges of living on land - as insects do - is preventing water loss. Without adaptations to their terrestrial environments, insects (and other land animals) would dry up! The excretory system of an insect is designed to reabsorb water from the urine so as little as possible is lost. Thin, wavy structures called **Malpighian tubules** take up wastes, water and nutrients from the blood, and empty everything into the digestive system. There, the **hindgut** reabsorbs almost all of the water (and the non-waste nutrients) and transfers it back into the blood. Wastes are then excreted in a very dry, concentrated form.

Reproductive: Most insects are **dioecious**, with separate males and females, and most are **oviparous**, meaning they lay eggs. Females produce sex cells (eggs) in a pair of **ovaries**, which are connected to the **vagina** by a series of ducts and chambers. In males, the sex cells (sperm) are produced in a pair of **testes**. During mating, sperm travel from the testes into a tube called the **ejaculatory duct**, where fluid produced in the **accessory glands** is mixed in. The sperm-containing fluid then passes on to the **penis**. The genitals - the vagina or the penis - are near the end of the body on the abdomen. Most insect species transfer sperm directly from male to female when they reproduce, but males of some species leave packets of sperm on their bodies or on the ground for females to pick up. Females store sperm in structures called **spermathecae** before using it to fertilize their eggs - sometimes for years!

Nervous: The **brain** in the head connects to two **nerve cords** that run down the length of the body, along the stomach. Sometimes, the nerve cords fuse together. Clusters of nerves in the different body segments, called **ganglia**, also connect the two nerve cords together. Sensory organs communicate information from the environment to the brain and nerve cords of the nervous system. Insects use three different kinds of "eyes" to sense their environment. Most adult insects have **compound eyes** that can see light and movement and form images. Many insects also use **ocelli** to sense changes in light intensity. Insect larvae have **stemma** - visual organs that form simple images. **Antennae** can taste and smell things, sometimes from very long distances, and are used to touch and feel the environment.

Some groups of insects also have **ears** to hear predators or members of their own species. The ability to hear has evolved at least 20 times in insects - so ears can be found in many different places on the body, including on the head, the thorax, the abdomen, the antennae, the mouthparts, and the legs! Because insect ears have evolved so many different times, their structure also varies widely. Some insects hear using a **tympanal organ**, a thin piece of tissue stretched over an air sac; some sense sound waves using their antennae; others use modified **tracheae** (tubes involved in respiration), **eardrums** and fluid; and yet others have completely different adaptations to sense sound.

Hormonal: Many parts of the insect brain secrete hormones for reproduction, diapause (dormancy when environmental conditions aren't good), moutling (shedding and replacing the outer body covering when growing) and metamorphosis (transition into another life stage).

Trematodes

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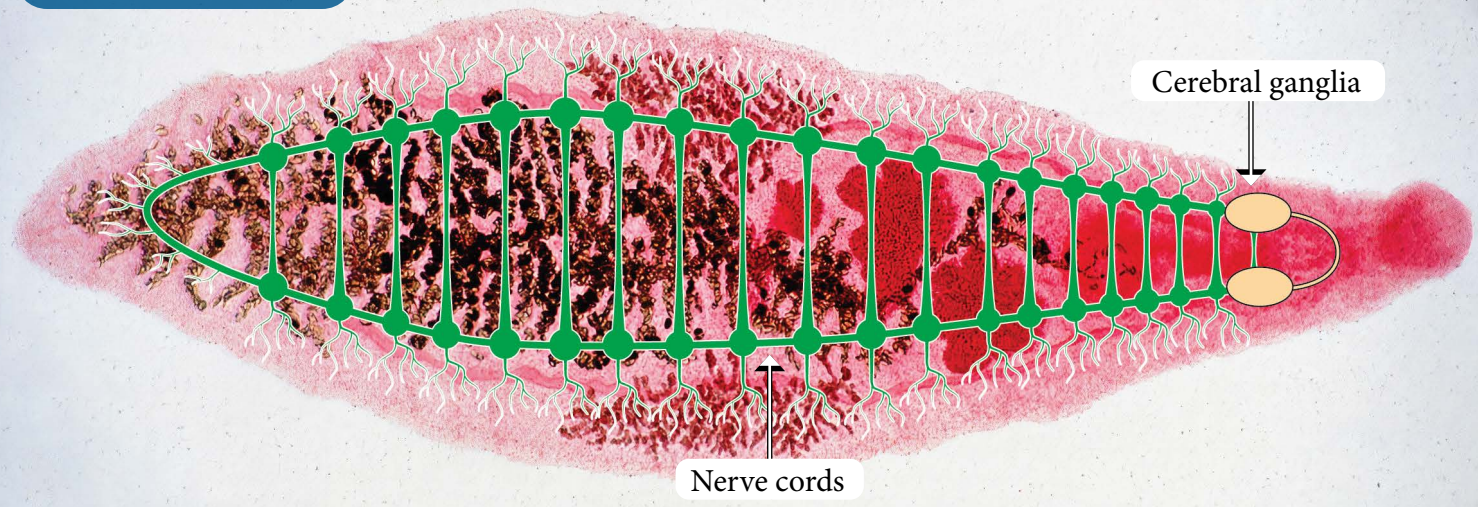
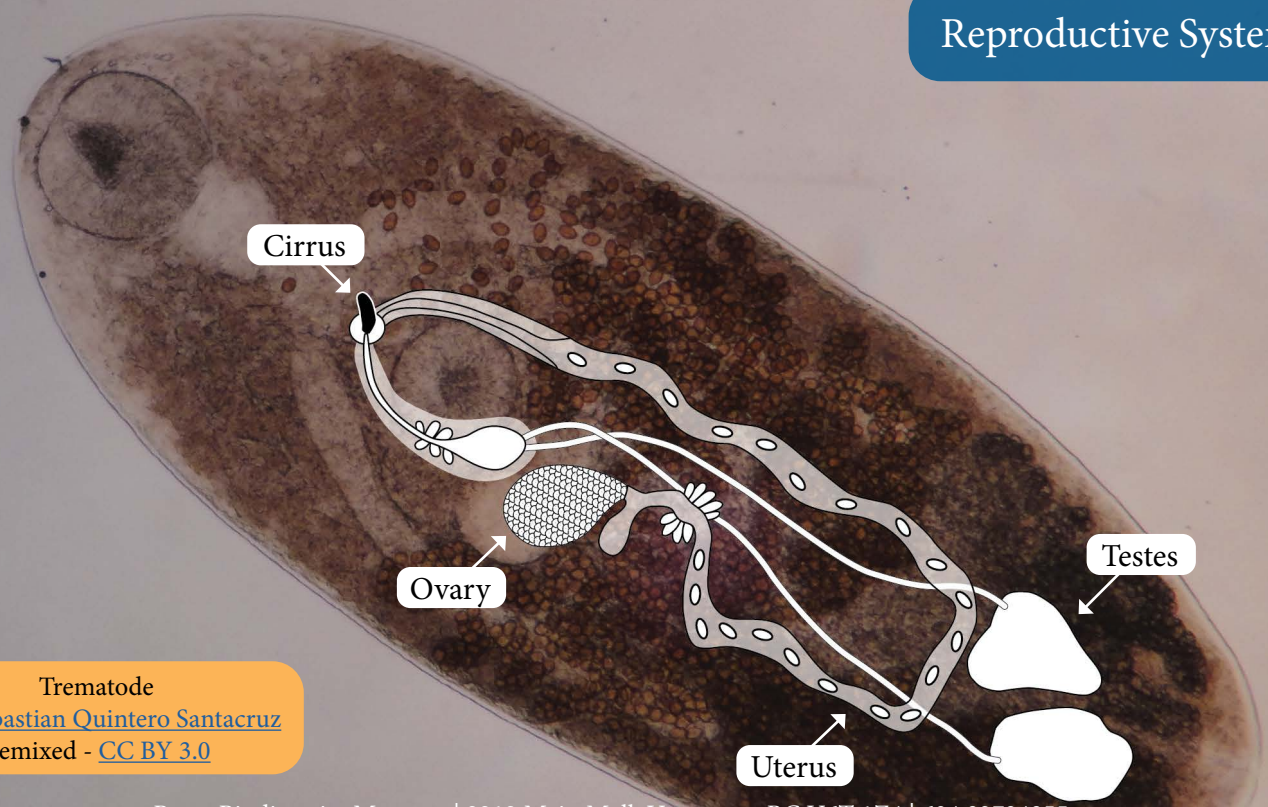
Nervous System



Dicrocoelium dendriticum
Alan R Walker
Remixed - CC BY-SA 3.0

Reproductive System



Trematode
Juan Sebastian Quintero Santacruz
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Trematodes[4,32,36]

Trematodes are a group of parasitic flatworms. **Parasitism** is a type of close interaction between species in which one - the parasite - benefits at the other's - the host's - expense. Parasites live on or inside their hosts, sapping nutrients and energy and diverting resources away from host growth, survival and reproduction. Some parasites also change their hosts' behaviour. Trematodes usually infect two or three different hosts during their complex life cycles, jumping from one to the next at different life stages. Because they're adapted to parasitic living, their bodies and body systems are highly modified.

Excretory: Trematodes have kidney-like structures called **protonephridia** that filter wastes out of the body. The protonephridia are connected to tubes and pores through which urine is released. Wastes are also excreted when they travel across the **tegument** - the outer body covering - and into the environment.

Reproductive: Trematodes are **monoecious** - individual worms have both male and female reproductive parts, and so produce both eggs and sperm. The male reproductive component is made up of the **testes**, where sperm is made, and which are connected to a reproductive organ like a **penis** or **cirrus** (depending on whether it pops out or is always out) by tubes. The female reproductive component includes an **ovary**, where eggs are produced; a **yolk gland** that produces nutrient-rich yolk for the eggs; a **shell gland** that surrounds each egg with a tough shell and stores sperm; and a **uterus**, where eggs are stored and laid. When trematodes mate, they line up so that each can transfer their sperm into the other's **vagina** or uterus, fertilizing the eggs.

Nervous: As their name suggests, flatworms like trematodes have flattened bodies, with a head region at one end and a tail region at the other. The nervous system of a trematode is ladder-like, with **nerve cords** running down the length of the body and nerves connecting them. Clumps of nerves (**cerebral ganglia**) form a brain-like structure at the head. In general, trematodes lack sense organs to see, hear, taste and smell their environment. These structures have been lost because of the parasitic nature of the worms.

Hormonal: Trematodes don't have endocrine structures or systems.

Sponges

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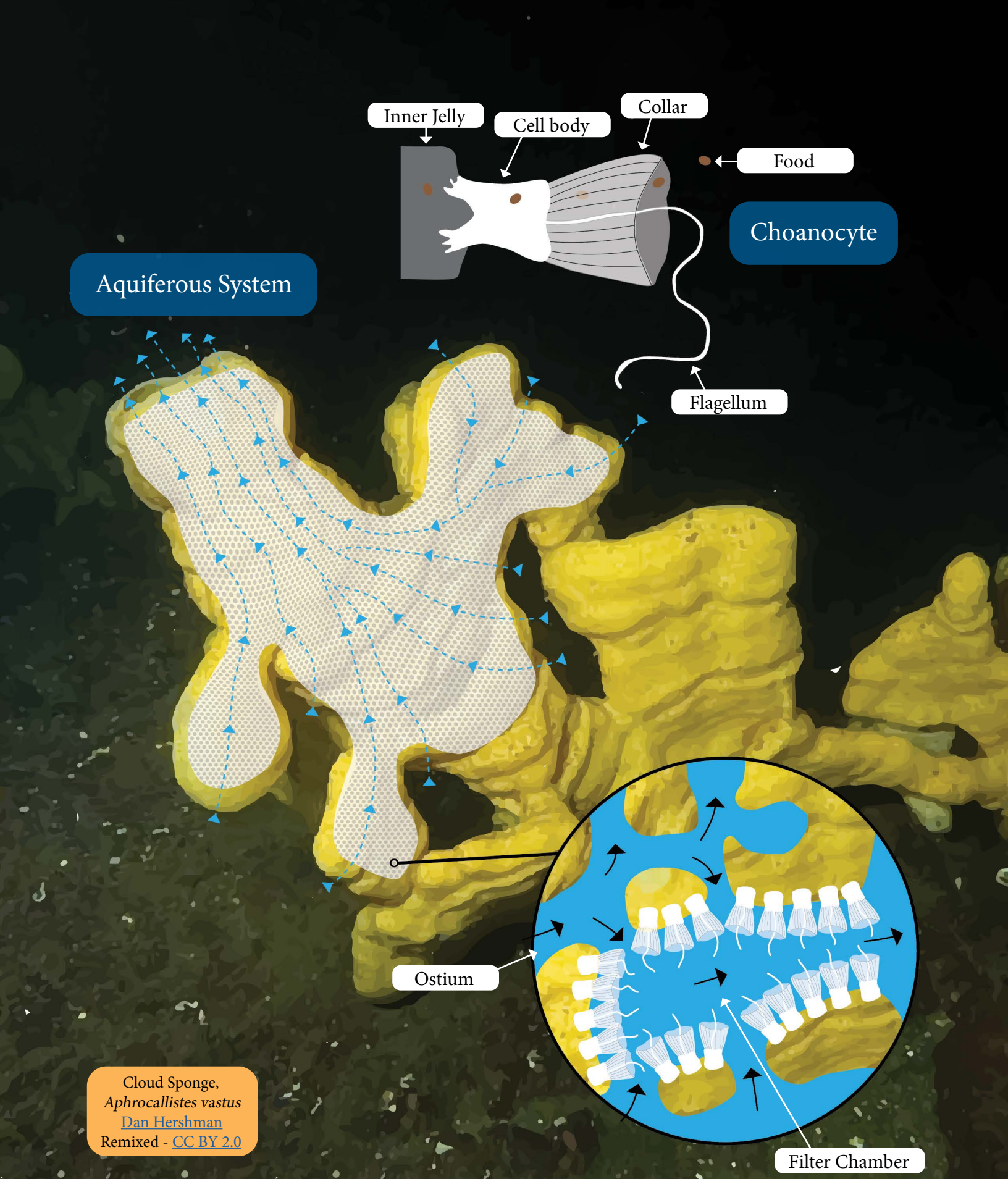

Cloud Sponge,
Aphrocallistes vastus
Dan Hershman
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Sponges[2,4,32,36]

These odd, non-moving creatures were thought to be plants by early biologists. In fact, they are members of the animal kingdom! Sponges rank among the most ancient animals on Earth, and have some of the most basal animal characteristics. The sponges biologists study aren't the household cleaner-uppers you have in your kitchen - most of the sponges people buy today are synthetic - but a group of mostly marine creatures with a distinctive way of life. Sponges' bodies are built around a network of internal passageways called the **aquiferous system**. The aquiferous system is made up of pores, channels and chambers, through which water flows. The aquiferous system does many of the things our different body systems do - not with tissues and organs, but with water and special cells called **choanocytes**.

Excretory: Choanocytes have a **flagellum**. Flagella are long, flexible "hairs" that some cells use to move themselves or fluids; for example, sperm cells swim using flagella. When choanocyte flagella beat back and forth, they create a current that brings water through openings in the sponge's exterior, into the aquiferous system, through the sponge's body and out through an opening at its top. Wastes are excreted into the water flowing into the aquiferous system and are carried out of the sponge.

Reproductive: Choanocytes also have a **collar**. The collar catches sperm cells that are released into the water by other sponges. Once caught, sperm is moved from the collar, to the cell body, to the jelly-like interior of the sponge where the eggs are. When sperm and egg meet, new baby sponges are made! Choanocytes turn into sperm cells that fertilize other sponges' eggs, too.

Nervous: Sponges do not have a nervous system - they don't have nerves or sensory structures.

Hormonal: Sponges don't have hormone-producing endocrine structures.

Please remember that...

Animals that are less "complex" than others are not "worse." Sponges have no tissues or organs, but have found success for hundreds of millions of years. There are tens of thousands of species of trematodes - many are human parasites! Insects and gastropods are two of the most diverse groups of animals on Earth. And echinoderms have streamlined their bodies to the point where water does many of the things our more "complex" tissues, organs and systems do.

Vertebrate animals (like us) are incredible. We are the product of billions of years of evolution. But our complex body systems do not make us better than other creatures. Each animal has a place in the world's ecosystems - just because that place isn't similar to our own doesn't make it any less valuable.

Animals and the tree of life

Animals are only one branch on the tree of life. Plants, fungi and different groups of protists, bacteria and archaea fill out the rest of the tree. Like animals, all of these organisms fulfill the basic processes of life - they just do it a little differently.

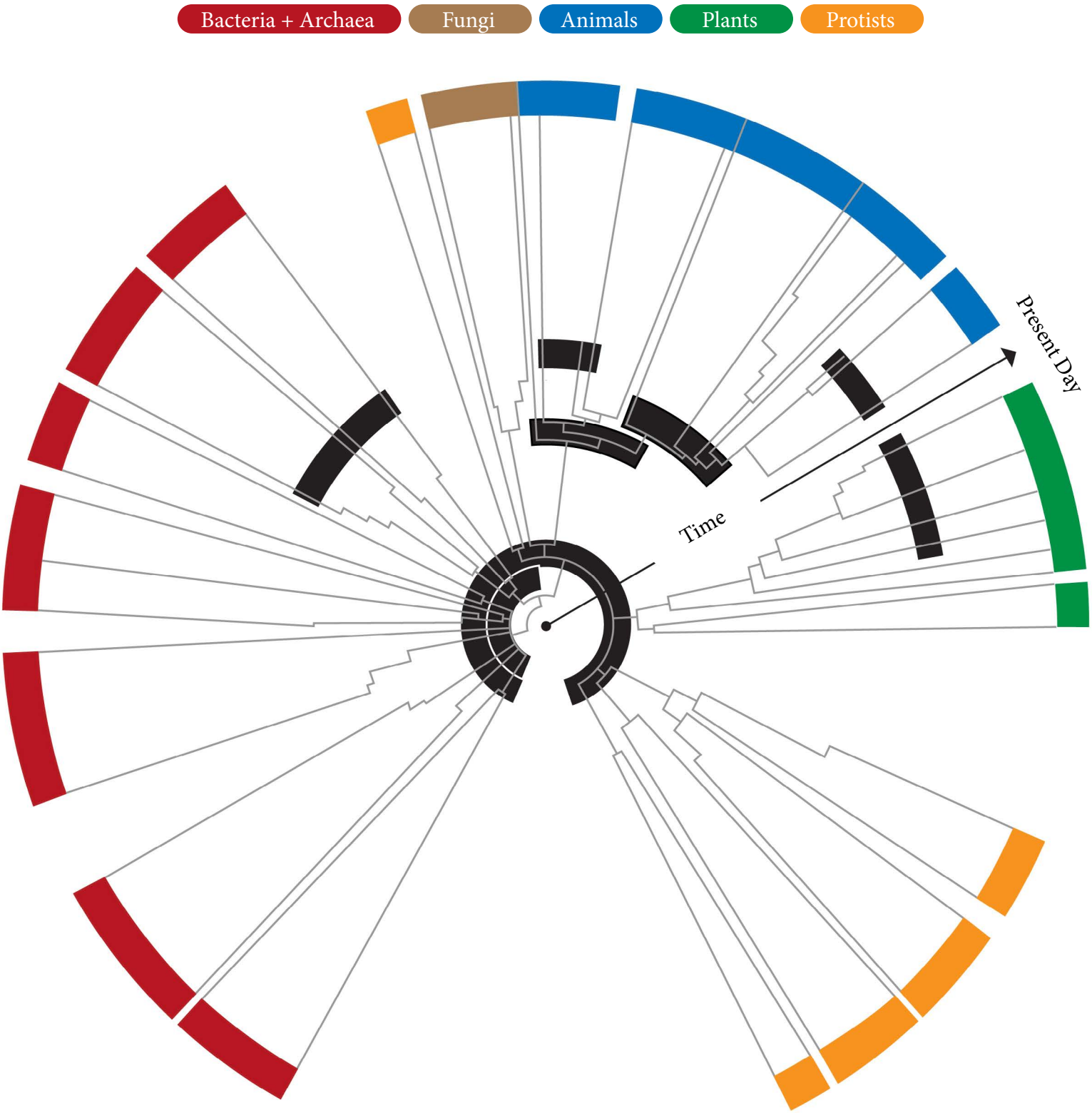
Plants[1,38,39,40,41,42]**:** Mosses, liverworts, ferns and horsetails reproduce using **spores**. Conifers like pine trees have pollen (sperm) and seed (egg) **cones** for reproduction. When pollen is blown to the seed cones by the wind, sperm and egg meet to produce **seeds**. Flowering plants also produce seeds, but their pollen- and egg-making structures are in **flowers**. Pollen can be transferred between flowering plants by animals as well as wind. Plants can respond to a wide range of environmental stimulus: light, gravity, chemicals, moisture, attack by animals… Changes in light are detected by cellular structures called **chloroplasts,** which are also the site of photosynthesis. **Hormones** communicate information about environmental change to different parts of the plant and coordinate responses.

Fungi[43]**:** Most fungi reproduce sexually by fusing their cells together and forming **spores**. Some fungi can also produce asexual spores that are clones of themselves. Yeasts grow little clones - buds - off of their own bodies. Fungi sense their environment using their **hyphae** - thin filaments that make up the fungal body.

Protists[2,44]**:** Reproduction in some protists, like red and brown algae, is a complex cycle of **spore** and **sex cell** production. Some single-celled protists reproduce "sexually" via **conjugation** - the joining of cells and sharing of DNA. Many also reproduce asexually. Algae and other light-capturing protists respond to environmental factors like sunlight, gravity and the movement of water. Other groups coordinate responses to stimulus, too.

Bacteria and archaea[45,46,47,48,49]**:** For the most part, bacteria and archaea reproduce asexually - and most reproduce by **binary fission**. During binary fission, a cell grows twice as big, copies its DNA and splits into two identical cells. Both bacteria and archaea are also able to reproduce "sexually" by transferring pieces of DNA between cells. **Receptors** on their cell surfaces sense the environment and coordinate responses.

The Tree of Life



Discussion questions

- Which animals are the biggest? What about their body systems lets them grow to be so big?
- Which animals are the smallest? What about their body systems keeps them from growing bigger?
- What are some of the differences between living in water and on land?
- Name some body adaptations to life on land.

Additional Activites and Resources

Video comparing the different ways mammals give birth:
youtube.com/watch?v=sz3Yv3On4lE

Video explaining the structure and function of insect brains:
youtube.com/watch?v=OQw3TNRnJ1I

Written by Jamie Clarke

Designed by Evan Craig

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