wildsight – Classification of Organisms
"Diversity of Life and Nature's Services"
Grade 6 Teacher Backgrounder

What is Scientific Classification?

Think of when you go to the zoo, how are the animals arranged? Typically they are organized so similar species are together, for example the reptile house or the birdhouse. If you read the signs next to the cages you will typically see a common name for the animal that you may recognize, and then also a Latin name for the animal. If you were to go to a zoo in Kenya to see the same animals, the common name would be in the local language, but the Latin name would be the same as the zoo in Canada. The reason that the Latin name is the same on opposite sides of the planet is because of scientific classification.

Scientific classification is **how scientists arrange extinct and living organisms into categories. It is a how scientists name these organisms in a common language so that all scientists across the world can communicate.** More recently classification has proven to be useful for tracing the evolutionary pathways along which present day organisms have evolved.

Scientists created categories based on natural similarities such as structure, development (reproduction and growth), biochemical and physiological functions (metabolism and senses) and evolutionary history. With so much to consider, new technologies that give scientists a deeper understanding of organisms, and new discoveries made everyday scientific classification is a dynamic and exciting branch of science that is constantly under debate.

A Brief History of Classification

For thousands of years scientists and common people have been classifying living organisms into categories. One of the earliest known systems of classifying forms of life is from the fourth century BC, when Aristotle first recognized some of the major groups of plants and animals. From approximately 1500-1750 several European scientists, who studied plants and animals, invented different systems to classify organisms. The invention of the microscope in the mid 1600s helped scientists to use microscope details to aid in their research. Much of the interest in classification was influenced by the influx of "new" (to Europeans) species being discovered from the increase of global exploration at the time.

In the mid 1700s Swedish scientist Carl Linnaeus created Taxonomy, **a system of classification and naming organisms**. Linnaeus built off the past theories of classification to create his own. It was his consistency and incredible volume of work naming new species that has made his system the basis of what some scientist use today.

Linnaeus became fascinated with plants and their names at a young age (probably when he was in Grade 6!). He went to university to study medicine. In those times you studied plants as part of learning to become a doctor. That is because doctors had to know how to make medicines out of plants. Linnaeus inevitably became more interested in studying plants to medicine. He became a professor of botany and went on many expeditions discovering and naming plants in Lapland. He published several editions of *Systema Naturae*, which is his classification of living things. Some of his students went on expeditions all over the world as naturalists who named and brought back to Europe many plants never seen by Europeans before. In fact, one of his students was the naturalist aboard Captain Cook's first voyage around the world, and brought back to Europe the first plant samples from Australia and the South Pacific.

What Linnaeus is best known for is his introduction of the method to modern classification. He insisted that every species have a unique Latin biomen or double name- the first half to be the

name of the genus common to several species and a second name that is specific to that species. This system of naming organisms that has become the official way that scientist have been naming new species and communicating to each other about living organisms. Before this system names were often very long and not consistent from scientist to scientist. No true names were accepted by the scientific community, which made communication difficult. For example the common wild briar rose, *Rosa canina* was identified by botanists as *Rosa sylvestris alba cum rubore, folio glabro* (roughly meaning pinkish white woodland rose with hairless leaves), and *Rosa sylvestris inodora seu canina* (odourless woodland dog rose). How was one to know if these names referred to one or two different species of rose?

In addition Linnaeus is known for his method of hierarchical classification, how he grouped the organisms that he named. The Linnaeus system works by placing each organism into a layered hierarchy of groups from general to specific. Each group at a given layer is composed of a set of groups from the layer directly below. The system was created so that you could figure out the taxa or kingdom of the organism by the biomen, or Latin name. Linnaeus originally identified that there were two kingdoms Animalia and Plantae. Today scientists believe that there are five kingdoms and some debate that these kingdoms can be placed into one of three Domains. Linnaeus's system is still used today, just in more detail.

Grouping of (taxa) taxonomy - from most general to most specific

Kingdom – To date there are five kingdoms or giant taxa. Animals are from the kingdom Animalia and plants form the kingdom Plantae. Other kingdoms are Monera (single celled prokaryotic-lack a nucleus) like bacteria. Fungi- moulds, mushrooms, lichens, yeast, etc. Protista- the simplest eukaryotes (paramecium that has a nucleus and membrane bound organelles) most are unicellular, some colonial, and some multi-celled. An example of a protist is algae.

Phylum – Phyla break the kingdoms into smaller more recognizable groups. For example the phylum Chordata includes animals that possess a skeletal rod of internal spine (vertebrae) like mammal birds, fish, and reptiles. Another major phylum in the kingdom Animalia is Anthropoda which includes spiders, insects and crustaceans (crabs, shrimp, and barnacles).

Class – Class breaks the phyla into even more familiar groups. For example the phylum Chordata is broken down into several classes, including Aves (birds), Reptilia (reptiles), Amphibia (amphibians), Mammalia (mammals) and several others.

Order – Includes several families of similar organisms. For example, the class Mammalia includes different orders such as Primates (Old and New world monkeys), Rodentia (mice, rats), Chiroptera (bats), Insectivora (moles, shrews), Carnivora (dogs, cats, weasels), Perissodactyla (horses, zebras), and many more.

Family – Orders can be further broken down into families. For example, families Felidae (cats), Ursidae (bears), Hyaenidae (hyenas, aardwolves), Mustelidae (weasels, wolverines), Canidae (dogs) and more belong to the order Carnivora, carnivores or meat eaters.

Genus – All the various species in the same genus have many common characteristics e.g. *Felis domesticus* (house cat) and *Felis concolor* (cougar). Both are cats and have

similar teeth, feet and claws but do not breed with one another to produce fertile offspring, which separates them as two different species in the same genus.

Species – is the smallest taxon defined as a population of organisms that share similar characteristics and that can breed with one another to produce fertile offspring.

The following is an example of the classification of a grizzly bear:

Kingdom- Animalia
Phylum- Chordata (having a spine)
Class- Mammalia
Family- Ursidae (Bear Family)
Genus- Ursus
Species- arctos (Grizzly Bear)

Linnaeus's thoughts about classification

Linnaeus grouped plants into taxa by observing the reproductive parts of the plants. For example, class was determined by the number of stamens (male organs) and the order was by the number of pistils (female organs). Lichens, fungi, mosses and other bryophytes where grouped into Class Crytogamia or plants with a hidden marriage because obvious sex organs were not present. Basically, Linnaeus grouped plants accordingly to physical properties with no regard of evolution. This is because he believed that all of the plants he was studying were directly from God's original garden of Eden and unchangeable. As a student of natural theology Linnaeus believed that since God created the world it was possible to understand God's wisdom by studying his creations. He thought that "naturalist classification" would reveal the divine order of God's creation. However, after years of observing plants he concluded that is was possible for plants to hybridize and adapt to new conditions. This suggests that some of the plants of today are not the same as from the creation of time. Linnaeus explained this as "still part of God's plan for creation for they had always potentially been present".

Linnaeus's school of thought and his system of hierarchical classification and binomial nomenclature has been modified, yet has remained the standard across the world for more than two hundred years.

Classification Today

Around the mid 1900s a new classification system was created by German biologist Willi Hennig. This system is called cladism or cladistic taxonomy. In grouping species, cladists look for "derived similarities", meaning those aspects that species can be expected to share by virtue of a common evolutionary ancestry, not key characteristics. They also want to change taxa to clades, which would reorganize the classification system so that each lineage had only one original ancestor for all of its descendents. For example, by tracing ancestral lines scientists have discovered that all land vertebrates were thought to originally been boney fish.

It is a tedious challenge for scientist to determine ancestral order. Nature has made this a difficult task because it is full of convergent evolution, adaptations, hybridizations, etc. For example a type of convergent evolution is insect mimicry, in which some insects that are edible come to superficially resemble other insects that are inedible, to escape from being eaten. It is called a polyphyletic error when a group is found to contain more that one ancestral line. Cladistics strives

to eliminate groups that are polyphyletic and reorganize them to have one complete evolutionary line. Cladistics does not assume any particular theory of evolution, only the background knowledge of decent with modification. Cladistics uses "cladograms" which not only shows the relationships between organism but also the amount of time that has passed since the last common ancestor between the two groups or species.

Scientists today use many forms of evidence to do their research including:

- DNA sequences
- hybridization studies
- biochemistry
- traditional morphology
- fossil evidence
- computational systematics (using computer programs to organize data)
- Scientists also rely on traditional knowledge when investigating native species.

When scientist use the local peoples knowledge to help recognize a vast number of organisms it is call this folk taxonomy. For example a team of scientist has been surveying in the Amazon for the past ten years identifying and collecting over 3,000 plants. Their purpose has been to maintain the native names, customs and traditional cultural knowledge. Local knowledge can also fill in gaps where species have hybridized or gone extinct.

Currently a new controversial movement is to abandon the Linnaean structure altogether and replace it with the PhyloCode. This means that cladograms and/or phylogenetic tree (which are a form of cladogram) would replace Linnaean hierarchical system. A phyolgenetic tree of life would be organized into three domains. The Eucarya domain would group together the fungi, plant, animal and protista kingdoms. There is also debate on abandoning biomens for single names or numeric codes. Imagine the paper work with that!

Why do we need to know about Scientific Classification?

Why classify living organisms and figure out the natural history of earth? Scientists do this for the same reason a writer might decide to break up the history of civilization into several volumes, many chapters, and a multitude of paragraphs. Both efforts are attempts to impart structure for an amazing amount of information.

By having one system and language to use when classifying organisms' scientist across the world can communicate and contribute to each others discoveries. By classifying organisms according to evolution and ancestry scientists get a glimpse into the past and can better understand how organisms adapt to change. This may help our understanding of global climate change.

With new discoveries made everyday ranging from discovered fossils, better computer programs, species being discovered and going extinct, classification is an ever changing field.

Did you know?

- Cladograms show that birds and crocodilians are closest relatives, descendants from a group of retiles called archosarus
- Protists are traced back 1.7 billion years

- The oldest forms of life are from the kingdom Monera and are estimated at 4 billion years old.

According to a United Nations report these are the estimated numbers of species identified:

Kingdom	Number of species worldwide
Monera	4,000
Protista	80,000
Animalia, vertebrates	52,000
Animalia, invertebrates	1,272,000
Fungi	72,000
Plantae	270,000
Total Number of described species:	**1,750,000**
Possible number of unknown species:	**14,000,000**

What are 'Nature's Services'?

Have you ever stopped to wonder what would happen if the trees just gave up producing oxygen? Or if the decomposers went on strike? Or what about if the water cycle stopped? Our daily lives depend on services we get from nature.
Ecosystem organisms and processes provide us with things that we often take for granted.

Ecosystem Services
(From wikipedia)

Humankind benefits from a multitude of resources and processes that are supplied by natural ecosystems. Collectively, these benefits are known as **ecosystem services** and include products like clean drinking water and processes like the decomposition of wastes. Ecosystem services are distinct from other ecosystem products and functions because there is human demand for these natural assets. Services can be subdivided into five categories: *provisioning* such as the production of food and water; *regulating*, such as the control of climate and disease; *supporting*, such as nutrient cycles and crop pollination; *cultural*, such as spiritual and recreational benefits; and *preserving*, which includes guarding against uncertainty through the maintenance of diversity.

The concept of naming and valuing 'Nature's Services' or 'Ecosystem Services' has interested economists as well as ecologists; imagine trying to place a dollar value on the things that we get from nature that sustain human life- for free! Imagine NOT valuing these things, and just assuming they will always be there.

The following is a list of the **17 services**, adapted from the book *Nature's Services: Societal Dependence on Natural Ecosystems*, by Gretchen Daley:

- water supply and purification
- waste treatment
- weather protection
- nutrient cycling
- air supply and purification
- temperature control
- u.v. protection
- raw material creation
- education and inspiration
- soil formation
- pollination
- food production
- sanctuaries
- genetic storehouse
- outdoor recreation
- land-loss minimization
- disease and pest control

Nature's Services and the Diversity of Life

The idea of nature's services fits nicely with the theme of 'diversity of life' and 'classification', because it is yet another way to look at ecosystem organisms, non-living elements, processes, cycles and interrelationships, and to classify them based on their role, job, or 'service' they provide. So with the 17 Services, we are building a classification based on function rather than form. This might seem a little anthropocentric, as we are looking at the services primarily from the perspective of service to humans, but it is a good way of recognizing our deep and inherent connection to nature, and our dependence on it. Not a bad concept to get across when developing future leaders who will have to meet the challenges of sustainability!
Nature is not something 'out there' as we often refer to it, but is very much a part of us and of our every day lives. We couldn't eat, drink or breathe without it!
In order to move toward ecological sustainability, everyone must understand these basic facts.

It is worth noting that areas on our planet which hold the greatest amount of biodiversity also provide the greatest number of ecosystem services- hence the 'diversity of life' and its preservation is very much interlinked with services that sustain us!

> *"Over billions of years a toxic stew of inorganic compounds has been transformed by cells into mineral deposits, forests, fish, soil, breathable air and water- the foundation of our economy and of our healthy existence. With sunlight as the sole energy supply those natural resources have been created in growing, self-sustaining cycles- the 'waste' from one species providing nutrition from another. The only processes we can rely on indefinitely are cyclical; all linear processes must eventually come to an end."*
>
> -Karl-Heinrick Robert, founder of the Natural Step

"Sustainability requires that our emphasis shift from 'managing resources' to managing ourselves*, that we learn to live as part of nature. Economics at last becomes human ecology."*

-Mathis Wackernagel and William Rees, authors of Our Ecological Footprint

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Kingdom Summaries

Before looking at the general classification of living organisms, what is a living organism? *An organism is the unit element of a continuous lineage with an individual evolutionary history.* Classical properties of living organisms include: reproduction, nutrition, respiration, irritability, movement, growth, and excretion. More modern definitions include the storage and replication of genetic information as nucleic acid, and the presence of or potential for, enzyme catalysis.

Below is a brief summary of the five Kingdoms of all living organisms.

Kingdom Monera

Members of this kingdom are prokaryotes, single celled organisms that lack a nucleus and other membrane-bound organelles. All Monera have a single chromosome that contains all DNA and most fix or ingest carbon. Many scientists believe that Monera is the oldest living organism on the earth, dating back 4 billion years. These scientists believe that photoautotrophic (organism that can produce its own food using photosynthesis) prokaryotes made our atmosphere aerobic. Monera is the only prokaryote kingdom and can be divided into two domains Archaea and Bacteria.

Domain Archaea – from the greek word *archein* 'to begin as in primitive or original'

1. Not susceptible to antibiotics
2. Usually found in extreme environments e.g rift vents in the deep sea, hot springs, extremely alkaline or acid waters, digestive tracks of cows, petroleum deposits deep underground.
3. Single celled organisms with no nucleus

Domain Bacteria –

1. More common than Archaea, found almost everywhere
2. There is more bacteria in your mouth than people in the world
3. Most bacteria will not make us sick, for example the bacteria on our skin prevent germs from attaching there
4. Found in food such as sauerkraut and cottage cheese
5. Found in fuels such as methane gas

<u>Ecological Roles:</u>

- Decompose organic material
- Autotrophic bacteria return oxygen to the air and remove carbon dioxide
- Cyanobacteria and bacteria in the roots of legumes convert inorganic nitrogen in the atmosphere to organic nitrates that plants can use
- Bacteria is used in sewage treatment to clean the water
- Bacteria is sprayed on oil spills, can clean up old mines, and used to solve other environmental problems
- Some bacteria can be used as antibiotics
- Some bacteria is used for research and in genetic engineering

- Domain Eukarya - All the other living organisms on earth belong to this Domain since all their cells have a nucleus and other membranous organelles (including mitochondria and chloroplasts). Living organisms in this Domain all:
- Unicellular and multi cellular
- Cell division by mitosis (process of nuclear division where the cell divides and has the same number of chromosomes as the original nucleus)
- Evolved from Domain Archaea

Kingdom Protista

This kingdom is not as defined as the others. It includes a grab bag of single celled, colonial and rarely multi-celled organisms that do not really fit in any other kingdom. In total there are 60,000 different species in this kingdom. All species share a few similarities including: membrane-bounded nuclei, numerous organelles, and contain DNA. The most common species in this kingdom are single celled. Some scientists believe that Protista are descendants of Bacteria from approximately 1.7 billion years ago.

4 major groups
1. protozoa
2. slime mold
3. unicellular algae
4. multi-cellular algae

Plant-like protists – Most common are algae, since it belongs to the only phylum that is autotrophic (makes its own food). In older classifications these were defined as primitive plants and are indeed plant-like in many respects because they have chlorophyll and are photosynthetic. Members include – diatoms, yellow-green algae and golden-brown algae, and dinoflagellates.

Animal-like protists – All other Protista ingest bacteria as a food source. Typical habitat for Protista is aquatic habitats such as the ocean, ponds, or water droplet in soil, to make locomotion easier. Typically Protista have appendages such as cilia or flagella or depend on water current to get around. Many Protistan groups lack chlorophyll and are not photosynthetic. In this classification is the unicellular animal Protozoa which are highly specialized. They are larger than bacteria, very mobile swimming rapidly in water or crawling along the bottom or on submerged objects propelled by the whip like motion of their long hair-like flagella. Paramecium use cilia, short hairlike structures to move and for feed. Amoeba have neither flagella nor cilia but move by a complex flowing.

Ecological Roles
- Base of marine food web
- Major oxygen producer in the Biosphere
- Consumer of bacteria
- Many have symbiotic relationships with other organisms

Kingdom Fungi

This Kingdom includes mushrooms, mold, yeast and more that help to break down nature's garbage. Fungi used to be included with plants because the organism is sedentary and like plants their cells have walls, but they lack chlorophyll and can't make their own food. These organisms are grouped together because they can breakdown just about anything with an organic component such as groceries, your leather shoes, dead animals, grass clippings and so on. Some fungi even grows in jet fuel and cause trouble by clogging fuel lines. All fungi are heterotrophs (feed on non-living matter or parasitic) that rely on extra-cellular digestion. This means that Fungi digest their food outside of their bodies and then absorb their food and nutrients through their cells. Fungi exist in the ocean and on land. With the exception of yeast, all Fungi are multicellular.

Some Fungi have developed symbiotic relationships with other organisms. This means that both organisms have a mutually beneficial relationship and they live continually attached to one another. For example Mycorrhizal Fungi live on the roots of plants and provide inorganic nutrients, resistance to some pathogens in exchange for organic sugars. Another example is Lichens that live in a symbiotic relationship with cyanobacteria or certain green algae. The cyanobacteria or algae produces food for the Lichen through photosynthesis and the Lichen provides a place to live, water and minerals for its partner.

Ecological Roles

- Food Source- Not just mushrooms but also yeast to make our bread rise. Also Lichens were consumed by many First Nations and are an important food for animals in the winter.
- Some Fungi can break down various forms of toxic pollutants
- Decomposers in the food chain
- Important for succession, some fungi such as certain lichens, break down rock and create fertile soil for plants to grow in.
- Certain Fungi are used as biological monitors for air quality since they can only grow where the air is clean
- Some Fungi such as Oomycetes (caused the potato blight) or Ascomycetes (Chestnut blight) have pronounced effects on nature and human history.
- Some Fungi is used in medicine such as penicillin.

Kingdom Plantae

Kingdom Plantae is the foundation of all land habitats and serves as Earth's primary autotrophs, which makes them the producers of the food chain. Kingdom Plantae is extremely important because all members fix inorganic carbon (from CO_2) and produce organic molecules and oxygen through photosynthesis. Plants make their own food for maintenance and growth. The cell walls of plants are unique to this Kingdom because they are made of cellulose, which provides support for plant cells and tissues. Also their cells contain chloroplast which is an organelle that is essential for photosynthesis. Members of the Kingdom Plantae are multicellular and can be found in the water and on land.

Non-Vascular Plants –
(Bryophyta - Liverworts, Hornworts and Mosses):

These small plants grow in moist places on damp rocks, logs, forest floor and wetlands, illustrating that they have never become fully adapted to the land from their ancestral aquatic environment. They depend on moist environments in two ways:

1. They retail flagellated sperm cells which must swim to the egg cells and,
2. Most lack vascular tissue (tissue concerned with internal transport such as xylem and phloem in plants).

Vascular Plants –
(Clubmosses/Spikemosses, Horsetails, Ferns, Seedplants – *Gymnosperms and Angiosperms*)

Clubmoss and Spikemoss – are low growing plants with small evergreen leaves. Many clubmosses form attractive ground cover.

Horsetails – much of the coal we use today formed from the dead bodies of these hollow and jointed stem plants with whorls of leaves at the joints. Horsetails were dominant during the Carboniferous period.

Ferns – evolved around the same time. They have well developed vascular tissue (internal transport tissue such as xylem and phloem) with true roots, stems and leaves. The leaves of the fern are most often divided into numerous leaflets that gives the plant a lacy appearance.

Seed Plants – are the most successful in fully exploiting the land-based environment. Spermopsida or seed plants are divided into two classes: gymnosperms (naked seeds) and angiosperms (enclosed seeds).

Gymnosperms: cycads, ginkos and conifers of which ovules become seeds are borne naked on the surface of the cone scales.

Angiosperms: the reproductive structure are flowers within modified leaves called carpells where the seed is enveloped by the ovary that develops into fruit. Within angiosperms there are two – monocotyledon and dicotyledon (cotyledon is a seed leaf which is a food-digesting and storing part of a plant embryo). Note the differences between dicot and monocots:

Dicots	**Monocots**
Embryos have 2 cotyledon	Embryos have one cotyledon
Has vascular cambium and secondary growth	Has no vascular cambium or secondary growth
Veins in leaf	Veins in leaf are parallel
Flower parts in multiples of 4-5	Flower parts in multiples of three

<u>Ecological roles</u>

- Recycle water through transpiration.
- Used in many medicines.
- Food for many organisms.
- Consume carbon dioxide and produce oxygen.
- Create structure in habitat, for example roots help prevent erosion, mats of plants create bogs, a climax forest can provide many vertical layers of habitat for other organisms.
- Provide shade and shelter from the elements.

Kingdom Animalia

This Kingdom is the most familiar to us, since we belong to it. We share this kingdom with other organisms that are multicellular (except for sponges), our cells create tissues, which are arranged into organs and then into organ systems. Also we digest food internally and do not have cell walls like plants do. Our life cycle is unique to all other kingdoms as well because animals arise from egg and sperm cells. Did you know that some scientists believe we arose from the sea?

Ecological Roles

- Consumers in the food web, helps to keep balance (and some times unbalance) of other organisms on earth.
- Provide food for other organisms including other animals.
- Many animals are used in research to figure out how the human brain works, if medicines will work, why we behave the way we do and so on.
- Animals have the ability to completely alter their environment from humans building lakes and roads to beavers cutting down trees to worms making tunnels in the soil.
- Dead animals are returned to the soil and become food for other organisms.

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