CHAPTER 9

INTRODUCTION TO ISLAND LIFE FORMS AND ECOSYSTEMS

9. 1. INTRODUCTION

9. 1. 1. Learning About Nature

The more we learn about nature, the more we realize there is a lot we don't know. The relationships among plants, animals, and their surroundings are very intricate. Since the relationships are so complex, we often unravel only the most obvious mysteries.

On the other hand, we do know a great deal about nature. We can understand much of it too, if we are willing to open our eyes and our minds. As future stewards of our islands, we need to learn more about our local animals and plants. We also need to continuously investigate our weather, climate, geology, and surrounding oceans as discussed in the previous unit.

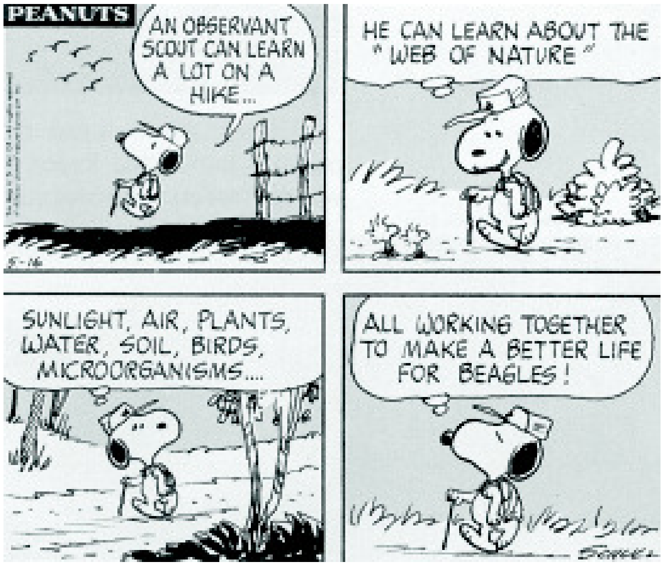
We should continue to study the ecological effects of people, both ancient and modern. Doing so, we can find clues that will help us see the inner workings of the natural world. In turn, we will be gaining the knowledge and skills that will help us in our future environmental decision-making. Therefore, to begin at the beginning once again, let us define what we mean by **ecology**.

9. 1. 2. Defining Ecology

Ecology is the word that describes this *comprehensive* way of looking at our islands, plants, animals, rocks, weather, oceans, etc. It derives from two ancient Greek words ***oikos***, meaning "house" and ***logos***, meaning *word* but interpreted more commonly to mean *to study*.

In simple terms, ecology is the scientific study of our surroundings; where we live. **Ecologists** are the scientists (people) who study ecology.

Ecologists try to understand how organisms relate to the other organisms around them. They want to know how such relationships affect the physical environment that all organisms live in. This way of studying organisms is part of the general science field of biology. Most professional ecologists have a good foundation in biology.



The obvious conclusions are usually the easiest to make.

Ecology, then, is the branch of biology that looks at the ways organisms interact. This interaction can be among organisms of the same type or with other organisms. Ecology further examines the effects the surrounding environment has upon all organisms.

You, your teacher, and your classmates are all investigating our islands in a scientific way.

Island ecologists study an island's ecology. They may also study an island chain's (archipelago's) ecology. In case you haven't figured it out yet, in a very real sense, you are an ecologist. Right now you are currently (and we hope carefully) studying our island's ecology. Reading this book is part of your study methods.

You, your teacher, and your classmates are all investigating our islands in a scientific way. Each of you is learning about our climate, weather, oceanography, geology, botany, zoology, etc., all in this one class.

You should also remember that the scientific method includes observing, predicting, experimenting, analyzing, documenting, and publishing research. The results of your ecological research may be important to our future welfare. Be sure to document it and to share it with others.

Part of our welfare and our heritage is the ecology of each of our islands. Future island ecology students will have a great interest in today's ecological conditions.

The scientific method includes observing, predicting, experimenting, analyzing, documenting, and publishing research.

Having a good understanding of an area's ecological change is important. While such information is always vital, unfortunately it has not always been available to our decision-makers since data was not properly documented or shared. In the past, people didn't always know to how great an extent we humans can impact our environments if we aren't careful. Remember that environmental studies is a relatively new field of science.

Now that we are more aware, we need to impress upon our leaders how much we care about our islands' ecology. We need to ask for their help in protecting the resources we are studying and appreciating.

One may feel it's a bit odd to think of our houses as being more than just the buildings in which we live. Learning about ecology helps us see that 'our home', or the place that we live in, includes the area surrounding our particular building and all the land beyond it. In a certain sense, the entire world is our home.

One only needs to read a newspaper to learn that changes in nature everywhere on the globe can affect us. Global warming, sea level rise, ozone depletion, overfishing, all of these larger global effects can affect our lives in very personal ways.

9. 1. 3. Ecological Responsibilities

Similarly, what we do has an impact on nature that may reach far beyond our houses and towns. The way we treat the environment today will leave its mark for hundreds of years to come. Our island becomes our children's island, and it is passed on continually. We can make our islands better or worse places for our children in the future.

We have an important responsibility to care for these islands and this entire earth-home of ours. We must keep it clean and make repairs when it is damaged. It is the only home we have. It is a big world and a big job.

A wise teacher once answered a student's question of "how to solve all the problems in the world." "One at a time" was the reply. Environmentally-minded professionals encourage the attitude of "thinking globally and acting locally." On our islands alone, there is a lot to do.

Gaining knowledge is the first step towards making wise decisions about nature. We need to understand our problems if we expect to solve them. While some of us may pursue careers in the natural sciences, we don't all *have* to be 'professional scientists' or scholars to study and learn from nature. Many of the greatest contributions to science came from amateurs.

9. 1. 4. Scientific Method and Ecological Studies

As well-trained ecologists, we must conduct our ecological research scientifically. We must make careful observations. By being careful in our work, our observations will be **precise** and **accurate**. The information (data) we gather will then be very useful.

We must make careful observations to ensure precise, accurate, and therefore useful data.

Scientists make careful observations and conduct well-designed experiments. Then they form and publish their conclusions. Ecologists cannot decide before they make their observations what the results will be. Ecologists write conclusions to carefully explain exactly what they learned. These results must come from their observations and experimentation.

Ecological researchers share their written results with other ecologists. By doing so they then receive professional advice and suggestions. Such advice will help future research become even more meaningful.

Finally, ecological books and journals publish the results of these studies. Other ecologists and scientists can then study this new information. It might help them while they are doing their own research on the same (or similar) questions.

9. 2. SPECIES AND HABITATS

9. 2. 1. Defining What a Species Is

Before we can discuss the composition of a biological community, we should once again begin at the beginning and define what we mean by the word **species**. Is it enough that two organisms look almost the same? The horse and the donkey look much alike, but generally we refer to them as two different species. Why?

Appearances can be deceiving. When a horse breeds with a donkey, almost always an infertile "**mule**" is the offspring. Clearly they cannot be called the same species. Only on extremely rare occasions will a fertile mule be the offspring.

(At the time of this book's writing, as far as this book's editor is aware, it has only happened one time. It turned out that the mule's *genes* had happened by chance to line up in just the right way. But, my apologies, we are getting a bit ahead of ourselves. More on these topics will be discussed in the next chapter. Now back to defining a species.)

If organisms are intentionally interbred and they produce fertile offspring, can we then think of them as being of the same species?

Brown bears and...

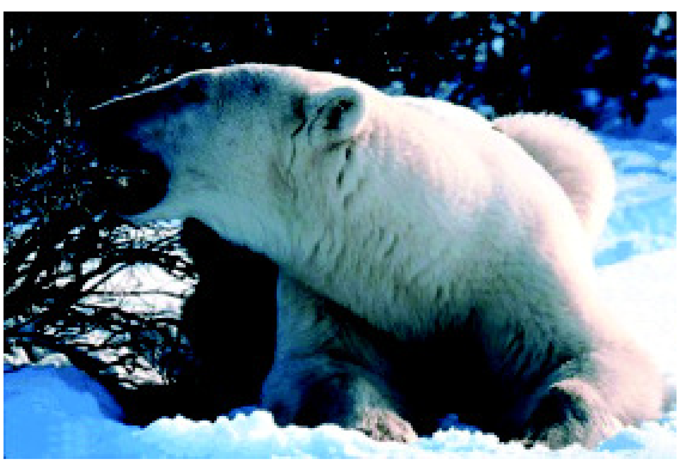
One example, albeit somewhat unfamiliar, is often referred to in this instance. Brown bears and polar bears interbreed in zoos and produce **fertile offspring**. However, at the time of this book writing, in nature, no such cross-bred offspring have been found.

An ecological barrier exists. These two species of bears occupy different habitats. The brown bear lives in temperate northern forests and the polar bear lives on iceflows and snowfields in the Arctic. Ecologists refer to these two organism groups as separate species.

How, then, can we define a species? Maybe a species is best defined as *a group of individuals more or less similar in appearance who are able to interbreed to produce fertile offspring in their natural environments.*

9. 2. 2. Species Composition and Habitats

Ecologists may want to identify all of the living organisms of a habitat or ecosystem. They may also want to find out how many species live there. They call these identifications that habitat's **species composition**. Scientists have documented the species composition of several habitats here in our islands. Finding where these are located requires a bit of *research* (recall our earlier emphasis on this word's root—*search*). One good place to start one's search is at our nearby resource management agencies and at our nearby institutions of higher learning.



...polar bears interbreed in zoos and produce fertile offspring. However, in nature, no such cross-bred offspring have been found.

This description helps current and future ecologists. They can understand the variety and the number of different kinds of organisms living within an area. "**Biodiversity**" is the word we now use to refer to these species' composition listings.

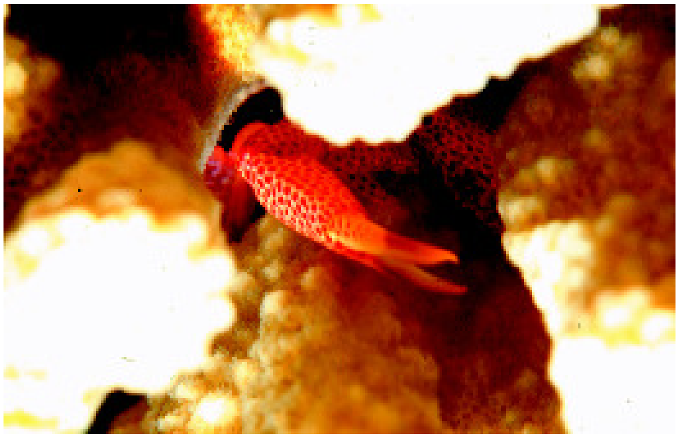
There are a number of different **habitats** present in each ecosystem. Where each organism lives within an ecosystem is that organism's habitat. Many ecological habitats have specific types of organisms which live only in that particular habitat.

Let us consider some of the habitats within a coral reef ecosystem. We consider the water from just above the corals up to the waters' surface to be one habitat. We sometimes call this area the *water column*. Many organisms live in the water column above the corals of our reefs. Still, they may never actually come into contact with the corals. Jellyfish, phytoplankton, and many fishes live here.

Within and among the corals themselves, another habitat of the reef ecosystem exists. Many small fishes and invertebrates live in the small cracks and crevices found within coral colonies. These are sometimes called a coral's **infauna**.

Many life forms are represented among the infauna of our reefs' ecosystems. Often only the *adult* forms of such species live within these small cracks and crevices. As adults, many refrain from ever swimming again into the open water column immediately above their colony.

Yet here amongst the crevices, these organisms mature, find each other, and spawn. Their gametes (eggs and sperm) enter the water column that flows above their hiding place. If fertilized, these eggs hatch into planktonic larva. After growing for a while, some of these offspring, by choice or by chance, then settle out of the plankton and return down into their species' exacting crevice habitat requisite. There each grows to become an adult. Then this new generation breeds anew.



Amongst the crevices of the coral reef, organisms such as Trapezia rufopunctata mature, find each other, and spawn.

Crabs, sandworms, and other invertebrates are common inhabitants of the *sandy habitats* below coral reef ecosystems. These include many mollusks that burrow into the sandy layers during the day. During the night, many of these organisms may crawl about onto the surface of the sands and corals searching for food or mates.

As we can see, a number of different habitats make up an ecosystem. Different types of organisms living in each of the habitats make up a single **biological community**.

Ecology is sometimes called the study of relationships. Ecologists group organisms that appear to be related in some way. Some of these groupings are discussed below.

9. 2. 3. Populations

One grouping is that of the **population**. A population is a group of organisms of the same species that live and interbreed together in the wild. A species generally contains many populations over its geographic range. In other words, all the population groups of an organism make up its species.

This can be confusing, but let's figure it out carefully. Our example shows the differences between the two terms *species* and *population.*

The common black sea cucumber, Holothuria atra, found in Saipan's waters, cannot breed with those living in the coastal waters of Luta, Tinian, or Guam.

The common black sea cucumber, *Holothuria atra*, occurs in the nearshore waters of each of our southernmost Mariana Islands. All of the sea cucumbers in the Mariana Islands, which exactly fit the description of *Holothuria atra,* are said to belong to the species *Holothuria atra.*

Members of the species *Holothuria atra* living in Saipan's waters cannot breed with those living in the coastal waters of Luta, Tinian, or Guam. The populations of sea cucumbers on these islands form separate populations. How do we know? Let's analyze it.

Sea cucumbers reproduce by **spawning**. The males and females both release their **gametes** (reproductive cells) into the water column where they meet with each other and fuse to form new sea cucumber larvae. Sea cucumber gametes cannot survive for very long periods.

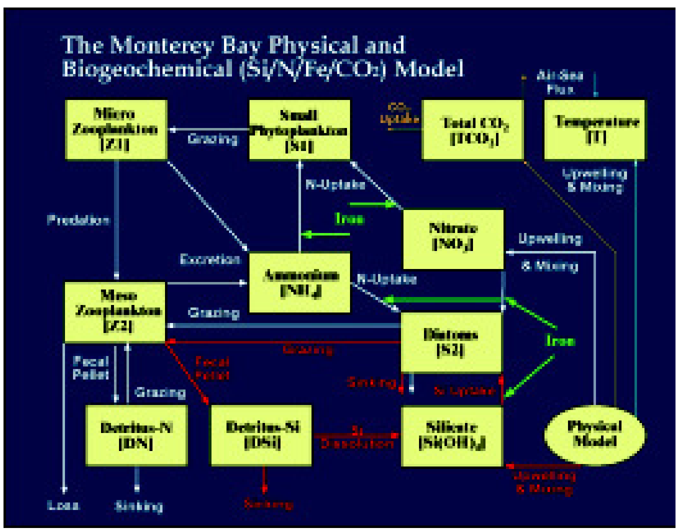
A gamete produced by a sea cucumber from one island could not survive the relatively long inter-island current flow voyage to fertilize any adjacent island's sea cucumber's gamete.

In the same way, any of the *Holothuria atra* found in our Mariana Islands cannot breed with any of those from other Micronesian islands such as Chuuk or Belau.

For this geographic-isolation reason there are distinct populations of *Holothuria atra* on each of our islands. They can only breed with others belonging to their same population. All of the populations considered together, around the world, make up the species "*Holothuria atra.*"

9. 2. 4. Ecosystems

A second and larger level of organization that ecologists define is the **ecosystem**. An ecosystem is the sum total of all living (**biotic**) and physical (**abiotic**) components found within a specific environment. An ecosystem usually contains many populations of organisms. It will also contain other non-living elements.



An ecosystem is the sum total of all living (biotic) and physical (abiotic) parts found within a specific environment.

To understand what an ecosystem is, again try to imagine a coral reef. We will start at the bottom and work our way up. Deep (1 meter or more) inside the sandy areas below and between the corals, there are bacteria living and dying. Each minute of the day; these bacteria consume essential elements from the sediments. They often release them into the waters above the sands.

On the base of a coral reef, there are many plants and animals living together. Above the corals, there is the open water habitat. It is teeming with various life forms, from plankton to sharks.

Above the water is the atmosphere. The atmosphere always affects the water below it (often through wind-driven waves, currents and rain, to name just a few influencing elements).

Landward (towards land) is the shore. The shore is an obvious barrier to coral reef environment. **Seaward** (towards the sea) there is the open ocean, where few (if any) adult reef-dwelling corals grow when the water is more than 300 meters deep.

Many separate environments surround the coral reefs. These environments (ecosystems themselves) are quite different from coral reefs. Each environment can have important effects on our reefs.

The influences one ecosystem receives from another ecosystem are called **inputs**. Inputs can be in the form of rain, land-based runoff, nutritional elements, heat, or something else.

A coral reef also affects the ecosystems that surround it. These ecosystem influences are called **exports**. An example might be the sand that reefs can add to coastal beaches. The oxygen that reef algae adds to the water and to our atmosphere is another example.

9. 2. 5. An Island Ecosystem Example

In case you are still not comfortable with the idea of an ecosystem, we will examine another situation. Let us consider a single island in the Northern Marianas (for example, Rota). We will compare it to an ecosystem.

On Luta (as in any ecosystem) there are living things (for example, bacteria, green plants, birds, fish and human beings, to name just a few). There are also many non-living things (for example; water, rocks, rain, sunlight, and the air surrounding the island).

Remember that the living things make up the *biotic* portion of the ecosystem. The non-living things make up the *abiotic* portion. We sometimes refer to these two portions as the *biological* and the *physical* components of an ecosytem. All of these parts affect the lives of organisms on Luta (as they do in any ecosystem). Both the biotic and abiotic portions relate closely to one another.

9. 2. 6. Ecosystem Complexities

Ecosystems are very complex. We soon realize that all of the components within a single ecosystem are **interdependent**. This means that a change in one of the parts will effect other parts of the ecosystem.

Ecology includes the study of how organisms interact with their environments. Often ecologists use the ecosystem concept as the starting point of many investigations. We do this to identify as many interactions as possible. Through studies, ecologists learn to *predict* the results (outcome) of environmental changes upon these interactions.

As future voters and decision makers, our decisions will affect many aspects of our islands' ecology. Each of us must learn to predict the expected consequences of our alternative choices and to determine which alternative we prefer.

Try to imagine Tanapag Lagoon without fish, or our TANGANTANGAN boonies without trees. Certainly these two habitats would not be the way we know them today. Every organism living within these habitats would be affected by their loss. These examples are, of course, drastic. However, they do illustrate how one part of an ecosystem (fish or trees) can have a substantial influence on the other parts of an ecosystem.

As we investigate nature, we soon realize that organisms living in an ecosystem must cope with all of the other parts of the ecosystem at the same time.

An example of this is what we, as humans, need to do when it rains. We must find shelter from the rain and avoid any flooding that the rain may cause. We must avoid lightning that may strike during the storm and find a safe place away from the storm's winds. Finally, we try to avoid the myriad of mosquitoes that come out after the rain stops.

As we can see, organisms have to worry about more than a single factor within an ecosystem. They must cope with all of the factors at the same time.

9. 2. 7. Identifying Some of Our Local Ecosystems

Now let us name some of the ecosystems found in our Northern Marianas.

The **Open Ocean** (far outside the coral reefs) is an ecosystem that surrounds all of our islands. The **Coral Reef** ecosystems are those we typically refer to as 'reefs'.

The Open Ocean (far outside the coral reefs) is an ecosystem that surrounds all of our islands.

Seagrass ecosystems are found in shallower water near the shore.

Coastal Casuarina equisetifolia ecosystems are an example of a beach ecosystem.

They are different from the **Seagrass** ecosystems found in shallower water near the shores. All of these are different from the **Beach** ecosystem, which is mostly out of the water. Inland from the beach, there are more land-based ecosystems.

Some land ecosystems include the **Forests** and **Savannas** found on our islands. Many different ecosystems can occur within a small area.

For example, there can be several different ecosystems, including each of these mentioned, in the relatively short distance of four miles, extending from two miles outside the reefs and then stretching inland two miles reaching the mountain tops at the center of our islands.

This can show us that ecosystems often influence neighboring ecosystems. One ecosystem effecting another is called **cross-ecosystem effect**.

An example of a cross-ecosystem effect, common in our islands, is that of sediment and nutrient runoff coming from the land. This runoff greatly influences our coastal seagrass beds and our coral reefs.

Because of these cross-ecosystem effects, are these three (land, sea grass beds, coral reefs) really only one ecosystem? It is sometimes very difficult to decide where one ecosystem ends and where an adjoining one begins. This is one of the problems ecologists encounter while studying ecosystems. Still, it is useful to refer to them separately and to study and describe their unique qualities.

Hopefully, the concept of an *ecosystem* is now firmly fixed in our minds. Hopefully, the seeds of the two fundamental science-motivating concepts of *questioning the accepted* and attempting to *define the heretofore indefinable*, may well have been placed there, too. If so, this is good.

Next we will explore some of the concepts and terms ecologists use while attempting to learn about ecosystems. We will also learn the concepts and terms describing the ecology of life forms contained within ecosystems.

9. 2. 8. Ecological Succession

Nature is forever changing. The changes may happen so slowly that we don't notice them. However, change is essential if living things are to thrive.

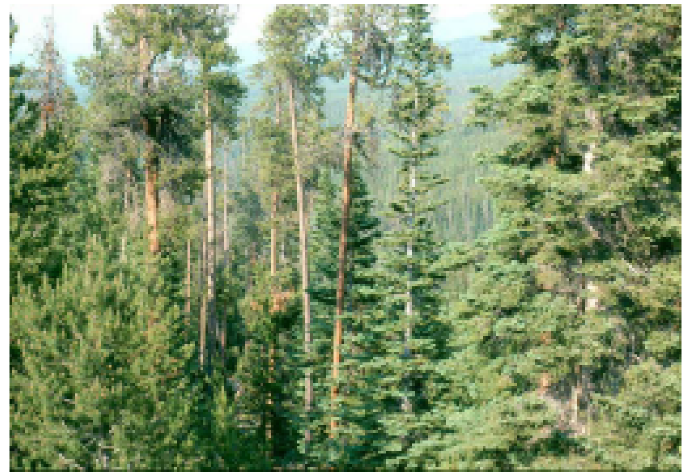
If we could watch a pond near a forest for many decades, we would see a gradual, remarkable change. Soil washing from the hillsides into the water slowly collects in the form of mud along the edges of the pond.

Grass seeds carried by the wind might take root in this new mud and grow. Soon the small grasses die. They mat down and decay, creating a nutrient-rich bed for larger rushes and sedges. Tadpoles of toads and small fish, such as mosquito fish and tilapia, find safety for awhile among the roots and stalks. Insects might lay their eggs on the leaves.

These plants and animals also die and their remains settle into the mud. Their decay builds more of the fertile soil, slowly raising and drying the edge of the pond. Bushes and small trees move in.

Over time, they also fall and form more earth. Large trees may finally grow into a stand called a **climax forest.** The former pond has completely disappeared.

The succession of stages from pond to mature forest can take hundreds or even thousands of years. Further changes will go on forever.



This climax forest in located in the US Rocky Mountains.

The slow, constant process of **succession** is at work everywhere on the face of the earth. To see it—and to see how humans can alter the environment—we need look no further than our own lawns.

If you were to ignore your lawn for a year, the neglected lawn would soon become covered with tall weeds and brush. These species will come from seeds carried by birds and the wind.

Leave a lawn alone for a hundred years and it will most likely become a forest, home to many kinds of plants and animals.

9. 2. 9. Ecological Diversity

A forest that has developed through the long process of *succession,* described above, has many kinds of plants and animals within it. It extends from *bacteria* in the muck at the bottom of a pond and the *protists* that feed upon them, all the way to the bitterns, monitor lizards, and other **predators** feeding on larger **prey**.

The nutrient chain is rich in its variety. This variety is known as **diversity**. It is one of the ways nature regulates change. If a certain kind of plant or a type of animal should die out, other species often quickly take its place.

Predators, such as these wolves, feed on larger prey.

For instance, an insect may infest and kill most of the coconut trees of a natural coastal strand forest, but the coastal forest itself would not disappear. Instead, GAGU, DA'OK, and HUNEK trees would fill in the holes where the coconut trees had been. The dead coconut trees would decay and become nutrients for these other species.

However, if there were only coconut trees in an artificially-maintained coastal forest, and no other kinds of trees, the area would lack diversity. Any species-focused threat to the coconut trees by insects or diseases would endanger the entire forest. Other trees would not be around to fill the void and the forest might well disappear.

Diversity acts as a *buffer* against drastic change. It allows an area to adjust gradually to new conditions.

9. 3. BIOLOGICAL CLASSIFICATION AND SCIENTIFIC NAMES

9. 3. 1. Identifying Organisms

Biology is the study of living things. It has recently been estimated that some thirty million different kinds of organisms may currently exist on our earth. (See the Insects Chapter).

Karl Von Linne first published his well-designed classification system in the book "Systema Naturae."

Eleven Common Names for *Dog*

French	chien
German	hund
Italian	cane
Spanish	perro
Polish	pies
Russian	sabaka
Dutch	hond
Hebrew	kelev
Japanese	inu
Hindi	kutha
Basque	txakurra

Common names vary among languages.

Organisms live in many different kinds of environments. The body structures, colors, feeding habits, and behaviors of organisms are different in each environment.

There had long been a great need for an *orderly classification* of all living things in order to study these diverse life forms in detail. Ever since **Karl Von Linne** first published his well-designed classification system in the book *Systema Naturae*, we have had a working system for biological classification (see below).

We also seek to understand the complexity of life. Beginning with the ancient philosophers, humans have constantly attempted to achieve a better understanding of organisms by classifying them into groups.

The naming of living things involves certain complications. Common names are inadequate for use in scientific classification for several reasons.

The most obvious problem is that common names vary from language to language. Since common names vary, the same type of organism can have more than one common name. This would interfere with free and easy communication between scientists from different countries.

Additionally, common names do not describe the organism as completely as does a scientific name. Consider the common name "worm." This name brings to mind an animal which is soft, slimy and cylindrical. But do all worms look alike? There are tape worms, round worms, flat worms, earthworms, marine sandworms, etc. Snakes were often referred to as worms (*as were medieval dragons, but that's another story altogether*).

Similarly, "Fowl," "Yard Bird," and "Chicken" all name the same animal. Through these examples, we can understand why a single system of naming organisms is needed by biologists. Such a system is called **taxonomy.**

Taxonomy is a division of biology. Taxonomy classifies living things. It is mostly based on relative similarities in body structure, **embryological** (early life stage) **development**, and **evolutionary history** (see next chapter).

Sometimes behavior patterns, including feeding habits, also help us to classify organisms. The main languages used in classification are Latin and Ancient Greek. This helps us achieve uniformity among the organisms' names from all parts of the world, since, as "dead languages," they don't change.

9. 3. 2. Classification Efforts

Nearly 2,000 years ago, the famous Greek philosopher **Aristotle** began to classify organisms in a systematic way. Since Aristotle, many scientists and philosophers have also made a number of attempts to develop better classification systems. Most encountered neither much success nor widespread acceptance.

9. 3. 3. Karl Von Linne' (Carolus Linnaeus) and Scientific Names

Karl Von Linne' (better known as "Carolus Linnaeus"), [1707-78], was a Swedish botanist. He devised a two-name system called the **binomial nomenclature** classification system.

Linnaeus' system was very successful and became widely accepted. Today, more than two hundred years later, we still use it.

In his system, every known *kind* of plant or animal on earth is given a two-part **scientific name**. That name is not shared with any other kind of plant or animal.

The first part of an organisms' name is the **genus**. The second part is the **specific epithet**. Both names together form the scientific name for the species. The scientific name for human beings is *Homo sapiens* (meaning "wise man.")

The genus is like a family name, which is shared with other relatives. The specific epithet is like a first name, which belongs to an individual. Just like Kapileo, Jose, or Sablan, Estrellita.

Our genus name "*Homo*" is shared with some of our prehistoric human ancestors who differed in some ways from ourselves. We can easily research and read about earlier people using scientific names such as *Homo erectus* and *Homo habilis* because of this shared genus name.

Notice that the first letter of the genus is capitalized. No other letter of the scientific name is. Also note that both the genus and species parts are italicized. Another way to indicate a scientific name is to underline it instead of using italics, e.g., Homo sapiens. Both ways are acceptable.

These formats should *always* be used when referring to a scientific name. Also note that the second part, or specific epithet (sometimes called the trivial epithet) is never used by itself. Always refer to a species name using *both* its genus and its specific epithet. Levels above the specific epithet can be referred to by using just one name.

If the specific epithet is either unknown or has already been referred to and is well understood, we commonly use a two-letter ending after the genus name to refer to it. These two letters are *s* and *p* followed by a period.

Homo sp. can be used to refer to all members of the human species that presently inhabit our planet. Adding another *p* can be used to refer to more than one specific epithet. For example *Homo spp.* can be used to refer to all human species, including those now extinct.

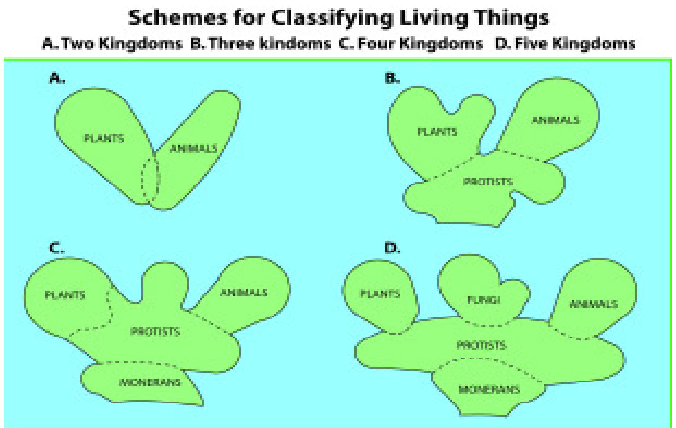
No matter how many common names are used for the same plant or animal, it has just one official scientific name throughout the world. As indicated, this makes it easier to look up information about any plant or animal.

On occasion, official taxonomic organizations (authorities for classification) may approve a request for a change of the official scientific name to a new, updated name. For this reason, it is important to stay up-to-date when working in biological taxonomy.

Nearly 2,000 years ago, the famous Greek philosopher Aristotle (depicted on the right) began to classify organisms in a systematic way.

This unit (and those that follow) commonly uses scientific names and their family groupings. In it, we will discuss several representative species of our islands and nearshore waters' ecosystems.

As students, you will be called upon to learn these representative species' scientific names (and yes, spelling counts!). Sometimes you will be asked to learn the family groupings as well. Studying and writing scientific and biological family names, accurately and often, helps one to remember them.



Various Kingdom classification methods exist.

9. 3. 4. Systematics

In addition to his two name binomial nomenclature contribution, Linnaeus also grouped the biologically identified organisms into a *hierarchy*. Linnaeus modeled his **biological hierarchy** after feudal days when there were Peasants, Knights, Dukes, Lords, and Kings. At the head of his hierarchy is the Kingdom level.

The most recent and, at the time of this book's writing, most-accepted system of classification is the **five kingdom classification system**. Other systems are also used (six, four, three kingdoms, etc.)

Despite years of debate, the precise number of kingdoms' is an issue that has yet to find any consensus amongst biologists. It is just too ripe for argument. With no 'authority' to settle the issues, it will most probably continue long into the future.

Each kingdom is progressively divided into smaller and smaller units. Each unit differs in qualities or *characteristics* in some way. Similar characteristics are grouped together. Each lower unit becomes more and more detailed. Each member of a lower unit has all of the characteristics of all of the categories above it.

The most detailed category in this classification system is the species level. You will recall that earlier in this chapter we defined a species as a group of organisms that naturally interbreed with one another. Additionally, they produce fertile offspring similar to themselves.

Classification of four organisms

	Human	*Dog*	*Honeybee*	*Live Oak*
Kingdom	Animalia	Animalia	Animalia	Plantae
Phylum (or division)	Chordata	Chordata	Arthropoda	Tracheophyta
Class	Mammalia	Mammalia	Insecta	Angiospermae
Order	Primate	Carnivora	Hymenoptera	Fagales
Family	Hominidae	Canidae	Apidae	Fagaceae
Genus	*Homo*	*Canis*	*Apis*	*Quercus*
Specific species	*Sapiens*	*familiaris*	*mellifera*	*virginiana*

The levels of classification are: Species, Genus, Family, Order, Class, Phylum, and Kingdom.

Recall that when referring to a species, one must state both the genus name and the specific epithet. Therefore, the species of humans is *Homo sapiens*. The genus is the next higher category in the classification scheme. A genus is a group of similar species.

The levels of classification are: **Species**, **Genus**, **Family**, **Order**, **Class**, **Phylum**, and **Kingdom**. Botanists (plant biologists) replace the word **Division** for **Phylum**, otherwise the ordering is the same. Also note that each of the above grouping names is capitalized, such as our now familiar **Family Hominidae** (which includes all of the *Homo spp.*) (Recently a level higher than Kingdom has become widely accepted, the **Domain** level.)

Between each of these levels, there are often sub-categories to help scientists further group organisms that don't quite fit into the other classification categories. A *Suborder* would be an example.

Whenever a new organism is discovered, taxonomists assign it a name using the methods of *binomial nomenclature*. Systematists then classify it using the *hierarchical biological classification system*.

9. 4. INTRODUCTION TO ECOSYSTEM ANALYSIS

Throughout your studies you will learn that ecologists have developed four rather different perspectives that are relatively standard. They use these perspectives as a focus for their studies of ecological subjects. These *focuses* or *models* are energy, cycles, population dynamics, and ecosystem structure.

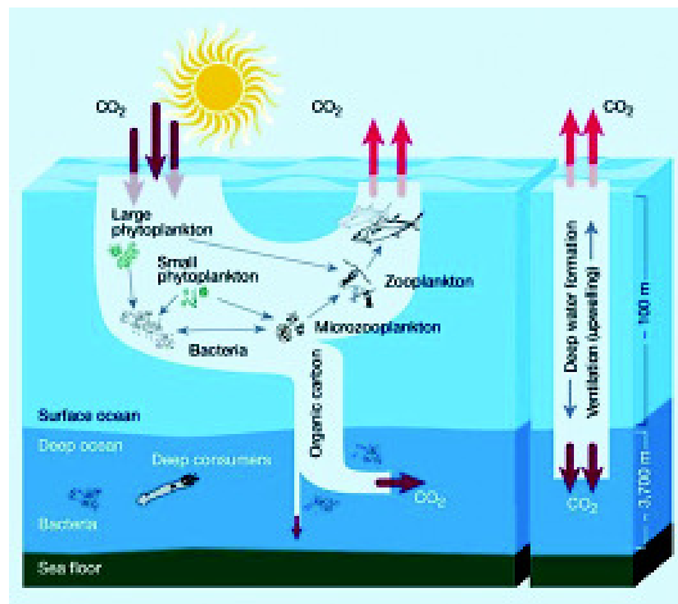
9. 4. 1. The Energy Focus

One model is the energy viewpoint. Energy is the cause of all biological activity. It transforms matter. Life exists only because it contains and uses energy. No energy, no life. When energy goes, so goes the possibility of life.

Some ecologists focus their studies on the flow of energy into, out of, and within ecosystems.

9. 4. 2. The Nutrient Cycles Focus

Interpreting nutrient cycles is a second way of looking at an ecosystem. These cycles are also called **biogeochemical cycles**. They include the oxygen cycle, the carbon cycle, the nitrogen cycle, the phosphorous cycle, and the cycles of various other minerals and materials.



The carbon cycle, shown here as it occurs in the ocean, is one of several biogeochemical cycles.

9. 4. 3. The Population Dynamics Focus

A third way of looking at an ecosystem's interactions is to learn about the nature of the populations of living things within in it.

Recall that all the members of one kind (species) of organism living within a given area constitute its population. The place where a particular population lives is its habitat.

Populations have unique characteristics and each faces unique ecological conditions. No two habitats are exactly the same. An individual organism might be born or die, but only populations have **birth rates** and **death rates,** and, as we'll learn in the next chapter, only populations can 'evolve'.

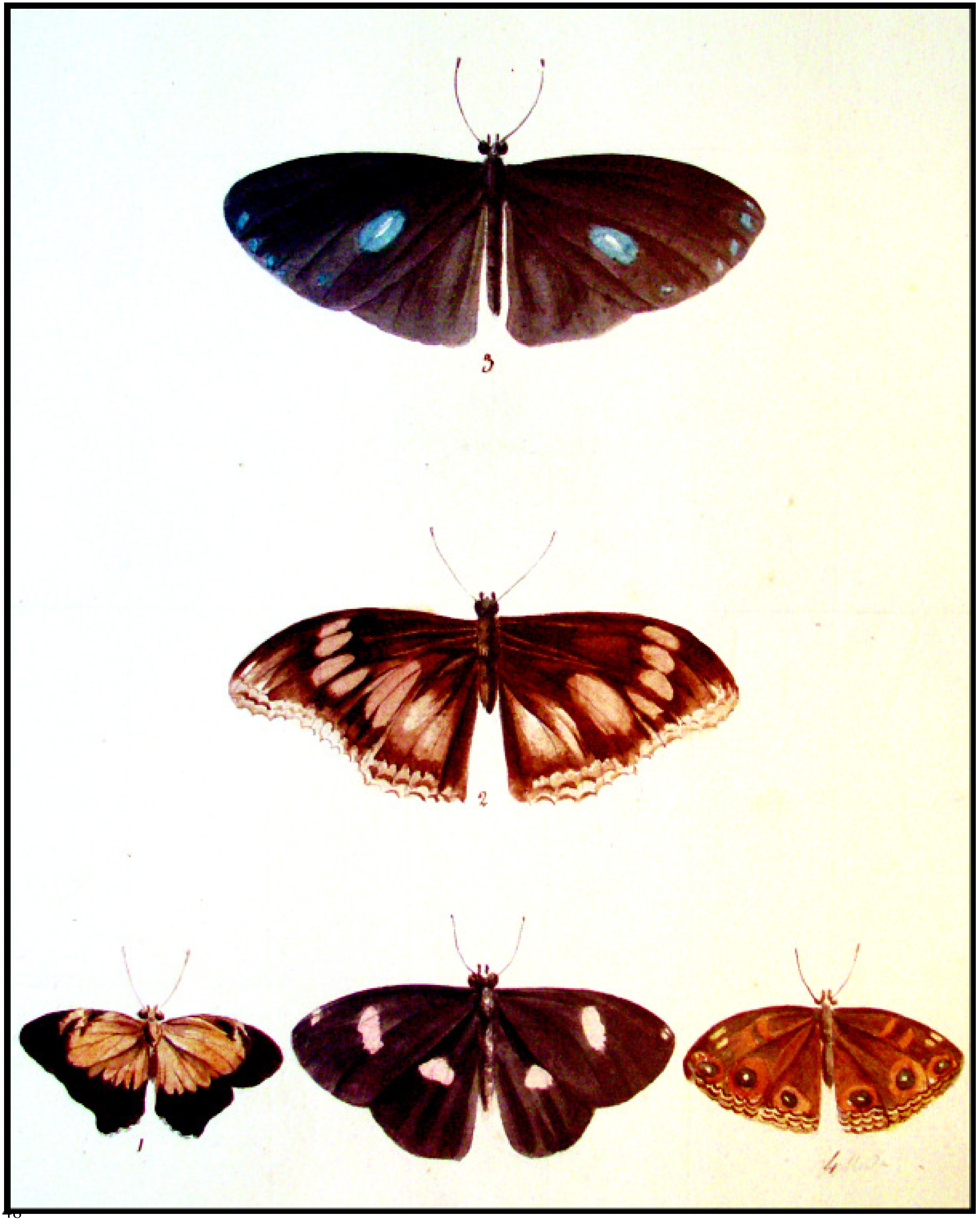
A population extends through time. It has its own birth (through *mutation* or *colonization)*, its times of expansion and contraction, and its own possible death (*extinction*). These terms will also be discussed in detail in our next chapter. One definitional note here however: a species becomes extinct when all of its populations are extinct.

9. 4. 4. The Ecosystem Structure Focus

Finally, some ecologists focus their attention on defining and observing changes in ecosystems. This could be called a communities or ecosystems viewpoint. You will soon discover that this viewpoint is the major one for this unit.

As we learned, in a process called *succession*, biological communities evolve from simple to more complex (mature) interactions. All the populations living in (*inhabiting)* a particular area form its biological community.

How a particular species' population lives within an area and uses its resources is called that species' **niche**. Again, these terms will be discussed more, and many examples will be given, in our later chapters.


3
2
1