Chapter II

The Diversity of Life on Earth

How incredibly diverse are life forms on Earth

A living fossil: *Gymnocrinus richeri*
Introduction Chapter II: The Diversity of Life on Earth

This chapter aims to expose how bio-diverse is the world we live in.

We, human beings, have inherited a planet which is currently inhabited by an incredible array of life forms resulting from 3.5 billion years of natural history and adaptations. Life forms inhabiting the planet range from large species such as mammals to microscopic organisms such as bacteria.

The more we study species the more we discover that we have so far only touched the tip of the iceberg in terms of how complex and bio-diverse is our planet.

We are still making remarkable discoveries, for instance finding species in places that we never thought species could survive or discovering links between species which have led to new paths of understanding of the history of life on Earth.

The reality is that there is still a lot to be discovered in biology. However, fields of biology such as taxonomy, the science of classifying species within their evolutionary history are disappearing. As species are disappearing at a much greater rate then they are studied, funding for research is now prioritized in conservation.

The fact that current species are no longer studied also means that we are losing a tremendous amount of knowledge and potential new ground breaking discoveries, some of which could have direct benefits to humans.

An important fact that we have discovered by studying life on Earth is that species are remarkably linked to one another in a complex interaction of food networks and ecosystems. All species play an important role in making the stable yet fragile ecosystems that we observe today.
Biodiversity is the variation of life forms within a given ecosystem, biome, or for the entire Earth. Biodiversity is often used as a measure of the health of biological systems. The biodiversity found on Earth today consist of many millions of distinct biological species, which are the product of nearly 3.5 billion years of evolution.
Biodiversity is like a web. Living organisms on the planet are connected and interrelated. Every organism has a role to play in a complex network of ecosystems.
II.2 Levels of Biodiversity

There are different levels at which biodiversity can be found:

- At the ecosystem level
- At the species level
- At the genes level

=> Species are interconnected in space and time

=> The vast majority of all species that have inhabited our planet have become extinct overtime
II.3 (a) Biodiversity: what do we know?

There are relatively only very few people worldwide who are doing scientific studies on species.

**Taxonomy:** The science of species classification requires a high level of expertise which is in decline worldwide (Each group of species requires experts to study and understand them).

Species are in fact disappearing at a much faster rate then they are studied.

We are losing hundreds if not hundreds of thousands of species each year. Species that we never had the chance to study and understand. Most of these are small or micro organisms.

=>The public knowledge of biodiversity loss is not understood as most institutions which classify biodiversity loss tend to focus on the well known mega fauna (tigers, elephants, rhinos...) but barely mention the much smaller organisms which often have a much greater role to play in ecosystems equilibrium.
II.3 (b)
Most species on Earth are very small in size for us humans. One has to look and search closely to find them.

When comparing ourselves to all living species on Earth, humans are truly “giants”.

Despite that most attention is on emblematic species (tigers, elephants...) the hidden macro world of biodiversity has a very important role to play and remains largely unknown.

=> Biodiversity mostly concerns the macro level in terms of species number.
II.3 (c) Biodiversity: what do we know?

Another trend in the study of nature is that there is an apparent disequilibrium between the knowledge that we have on different groups of species.

Some species with a broader interest from the general public have been well studied such as butterflies, shells, fish, birds, large mammals...

While others, usually smaller species, such as bacteria remain largely unknown.

Some groups such as insects, fungus or bacteria are also much broader than other groups.

The more we study species and try to get a broader view of the diversity of life on Earth, the more we realize that we know in fact very little about the variation of life forms on our planet.
II.3 (d)
While most conservationists focus on the preservation of emblematic species, thousands of unknown species are disappearing every year without being noticed.
II.4 (a) Taxonomy Vs Molecular Phylogeny

The discovery of DNA and the genetic revolution of the 20th century has driven a drastic change in how species are studied.

Taxonomy tends to be replaced by so called “bar coding” of particular genes within species. Each species having its own “Bar code” allows the buildup of a global database of species on Earth based on their genetic code.

However, there is a downturn to this process. The “species bar code” would work well if species were studied and identified at the same rhythm as they are scanned. However, this is not the case and we are now building-up large databases of species which we do not know about for the simple reason that they have not been scientifically studied to date (the possession of part of a species genome does not replace studying them).

Even more of concern, species are becoming extinct at a much greater rate then they are actually studied, which implies that many of the coded species are likely to be extinct before they have been studied.

Studying species implies looking into their anatomy, classifying them within their evolutionary history, studying how they interact with the environment...there is a lot to learn in doing such studies and potential applications which could benefit human beings.
II.4 (b)

In fact, one of the few things that we do know about biodiversity on Earth is that we still know very little...
II.5 (a) Speciation and Adaptation

Species on the planet have evolved over hundreds of millions of years in response to environmental pressures through the process of evolution by natural selection.

As such, every species on the planet are marvells of adaptation to given conditions and surrounding environments (they have managed to survive over a very long time due to the fact that adaptations that they have developed has giving them survival advantages).

Each species is unique with specific adaptation attributes from which a lot of knowledge and applications for human civilizations could be gained.

As such, any species becoming extinct results in irreplaceable loss in potential solutions/remedies.

Furthermore, biodiversity is an important aspect of the beauty of this planet. Let’s imagine a world with only a few species left including our own. Such scenario would be devastating for future generations.
II.5 (b)
Due to natural pressures species have evolved to be adapted to their surrounding environment.

In this picture a small species of crab from Loyalty Islands (New Caledonia) has camouflaged itself to match the species of algae on which it lives on. This common adaptation gives species the advantage of not being easily noticed by predators.
II.5 (c)
Pressures for survival drives long term adaptation in species.
II.6
The tree of life. All species on Earth are interrelated.
II.7 Archaea

The Archaea: are a group of single-celled micro-organisms. They have no cell nucleus or any other organelles within their cells.

Three main branches of evolutionary descent are the Archaea, Eukarya and Bacteria.

Archaea are further divided into four recognized phyla, but many more phyla may exist.

Classifying the Archaea is still difficult, since the vast majority have never been studied in the laboratory and have only been detected by analysis of their nucleic acids in samples from the environment.
II.8 Bacteria

The bacteria are a large group of unicellular microorganisms.

Bacteria are found in every habitat on Earth, growing in soil, acidic hot springs, radioactive waste, water, and deep in the Earth's crust, as well as in organic matter and the live bodies of plants and animals.

There are typically 40 million bacterial cells in a gram of soil and a million bacterial cells in a millilitre of fresh water; in all, there are approximately five nonillion bacteria on Earth, forming much of the world's biomass.

Bacteria are vital in recycling nutrients, with many steps in nutrient cycles depending on these organisms, such as the fixation of nitrogen from the atmosphere and putrefaction. However, most bacteria have not been characterized, and only about half of the phyla of bacteria have species that can be grown in the laboratory.

=> We still know very little about bacteria.
II.9 (a) Eukaryotes
(Plants, Fungi, Animals)

A eukaryote is an organism whose cells contain complex structures protected by membranes. The defining membrane-bound structure that sets eukaryotic cells apart from prokaryotic cells is the nucleus, or nuclear envelope, within which the genetic material is carried. Most eukaryotic cells also contain other membrane-bound organelles such as mitochondria, chloroplasts and the Golgi apparatus.

Almost all species of large organisms are eukaryotes, including animals, plants and fungi, although most species of eukaryotic protists are micro-organisms.

Cell division in eukaryotes is different from that in organisms without a nucleus (prokaryotes). It involves separating the duplicated chromosomes.

There are two types of division processes. Mitosis, one cell divides to produce two genetically identical cells. And Meiosis, which is required in sexual reproduction.
II.9 (b)
Biodiversity is the most valuable resource on the planet and yet the least understood...

As species are highly adapted to their surrounding environments, each species would require an in depth study to understand the processes involved. Even if every person on the planet was to study one species, we would still have far from a complete understanding of how diverse and complex the living world is. Yet, only a handful of people are making such studies

=> There is so much more to discover and yet so little allocated resources to do so...
II.10 Plants

Belonging to the kingdom Plantae, they include familiar organisms such as trees, herbs, bushes, grasses, vines, ferns, mosses. The scientific study of plants, known as botany, has identified about 350,000 extant species of plants, defined as seed plants, bryophytes, ferns and fern allies. As of 2004, some 287,655 species had been identified, of which 258,650 are flowering and 18,000 bryophytes.

“Green plants” obtain most of their energy from sunlight via a process called photosynthesis.

Aristotle divided all living things between plants (which generally do not move), and animals (which often are mobile to catch their food). In Linnaeus' system, these became the Kingdoms Vegetabilia (later Metaphyta or Plantae) and Animalia (also called Metazoa).

Since then, it has become clear that the Plantae as originally defined included several unrelated groups, and the fungi and several groups of algae were removed to new kingdoms.
II.11 (a) Fungus

A fungus is a member of a large group of eukaryotic organisms that includes microorganisms such as yeasts and molds, as well as the more familiar mushrooms. The Fungi are classified as a kingdom that is separate from plants, animals and bacteria.

One major difference is that fungal cells have cell walls that contain chitin, unlike the cell walls of plants, which contain cellulose.

Abundant worldwide, most fungi are inconspicuous because of the small size of their structures, and their cryptic lifestyles in soil, on dead matter, and as symbionts of plants, animals, or other fungi. They may become noticeable when fruiting, either as mushrooms or molds.

Fungi perform an essential role in the decomposition of organic matter and have fundamental roles in nutrient cycling and exchange.
II.11 (b)
The disappearance of only one species can result in the disappearance of many others which depend on it to survive...

Species are closely interrelated. For instance certain species of insects are only found on one species of plant. If this plant disappears, so will the insect species. Such principle applies to all living organism, the more we study species the more we learn that numerous other species live on or in dependence to one single species.

=> parasitology is a particular case of these interactions.
II.12 (a) Animals

Animals are a major group of mostly multicellular, eukaryotic organisms of the kingdom Animalia or Metazoa. Their body plan eventually becomes fixed as they develop, although some undergo a process of metamorphosis later in their life. Most animals are motile, meaning they can move spontaneously and independently. All animals are also heterotrophs, meaning they must ingest other organisms for sustenance.

Most known animal phyla appeared in the fossil record as marine species during the Cambrian explosion, about 542 million years ago.

Animals have several characteristics that set them apart from other living things. Most animals are eukaryotic and are multicellular, which separates them from bacteria and most protists. They are heterotrophic. Generally digesting food in an internal chamber, which separates them from plants and algae. They are also distinguished from plants, algae, and fungi by lacking rigid cell walls. All animals are motile. In most animals, embryos pass through a blastula stage, which is a characteristic exclusive to animals.
II.12 (b)  
Isolated ecosystems such as caves hold some of the most remarkably adapted species. There is still a lot to be discovered in remote ecosystems...

Remote ecosystems can be defined as places which have become isolated from their surrounding environments and which possesses unique environments. Even in the 21st century, many of such ecosystems on Earth, remain virtually unexplored for their inhabiting biodiversity.
II.13 (a) Insects

Insects are a class within the arthropods that have a chitinous exoskeleton, a three-part body (head, thorax, and abdomen), three pairs of jointed legs, compound eyes, and two antennae. They are among the most diverse group of animals on the planet, include more than a million described species and represent more than half of all known living organisms.

The number of extant species is estimated at between six and ten million and potentially represent over 90% of the differing life forms on Earth. Insects may be found in nearly all environments, although only a small number of species occur in the oceans, a habitat dominated by another arthropod group, the crustaceans.

The life cycles of insects vary but most hatch from eggs. Insect growth is constrained by the inelastic exoskeleton and development involves a series of molts.
II.13 (b)
Many insects are considered pests by humans. However, we must keep in mind that insects are vital to maintaining healthy ecosystems necessary for humans well being.
II. 13 (c) Insects

Insects that undergo incomplete metamorphosis lack a pupal stage and adults develop through a series of nymphal stages.

The higher level relationship of the hexapoda is unclear. Fossilized insects of enormous size have been found from the Paleozoic Era, including giant dragonflies with wingspans of 55 to 70 cm.

The most diverse insect groups have coevolved with flowering plants.
I.13 (d)
Insects represent the largest and most diverse animal group on the planet.
Mammals (formally Mammalia) are a class of vertebrate, air-breathing animals whose females are characterized by the possession of mammary glands while both males and females are characterized by sweat glands, hair and/or fur, three middle ear bones used in hearing, and a neocortex region in the brain.

Mammals are divided into three main infraclass taxa depending how they are born. These taxa are: monotremes, marsupials and placentals. Except for the five species of monotremes (which lay eggs), all mammal species give birth to live young. Most mammals also possess specialized teeth, and the largest group of mammals, the placentals, use a placenta during gestation.

There are approximately 5,400 species of mammals, distributed in about 1,200 genera, 153 families, and 29 orders.

Mammals range in size from the 30-40 millimeter (1- to 1.5-inch) Bumblebee Bat to the 33-meter (108-foot) Blue Whale.
II.14 (b)
Mammals have developed some of the most complex behaviors in the animal kingdom.
II.15 (a) Reptiles

**Reptiles**, or members of the (Linnaean) class Reptilia, are air-breathing, generally "cold-blooded".

Their skin is usually covered in scales or scutes. They are tetrapods (either having four limbs or being descended from four-limbed ancestors) and lay amniotic eggs, in which the embryo is surrounded by a membrane called the amnion. Modern reptiles inhabit every continent with the exception of Antarctica.

Four living orders are currently recognized: Crocodilia, Sphenodontia, Squamata and Chelonia.

The majority of reptile species are oviparous (egg-laying), although certain species of squamates are capable of giving live birth. This is achieved by either ovoviviparity (egg retention) or viviparity (birth of offspring without the development of calcified eggs).

Many of the viviparous species feed their fetuses through various forms of placenta analogous to those of mammals, with some providing initial care for their hatchlings.
II.15 (b)
Reptiles have adapted remarkably to the most hostile environments.
Conclusion Chapter II

As presented in this chapter, species on Earth are incredibly diverse.

However, despite that main types of life forms have been identified and can be recognized, most of the diversity occurs between species.

Despite that individual species within a group have common features, they also possess very different traits and adaptations which accounts for the diversity.

While we are now starting to get a good understanding of the common traits in groups of species, adaptations at the species level remains virtually unknown.

=> Every species is unique.