MARINE BIODIVERSITY

Brunel, Pierre
Département de Sciences Biologiques, Université de Montréal, Canada

Keywords: marine, biodiversity, ecological, species, oceans, genetic, taxonomic

Contents

Summary

The huge variety of plants, animals and microbes, their genes or hereditary units and the landscapes which they build, all of these components of the living world (or biosphere) on our planet make up what is called Biodiversity (or biological diversity). Most of this diversity is unseen by most people, primarily because the vast majority of living organisms are too small and hidden in vegetation, in soil, in coral reefs, and in the muds and sands covering the bottom of the oceans, lakes and rivers. Yet many of these organisms are essential to the well-being of humans, either directly as renewable resources with market value, or indirectly in maintaining a certain ecological equilibrium in present-day nature. Such equilibrium is presently being broken in several places on our planet, because industrial Man has removed too many species, not accounting for the value of ecological services in our myopic way of assigning monetary value only to short-term goods and services. Aspects of Earth's biodiversity focus either on species, on high-level taxonomic groups, on their underlying genetics, or on ecosystems and their functions and services to humankind. Methods of acquiring knowledge of these four kinds of variety of life are outlined. Marine species diversity is harder to know, but is probably smaller than land and freshwater diversity, but high-level biodiversity is much larger in the sea. Figures are presented for the major phyla and classes of animals, and examples of new and recent major discoveries are presented. Marine ecological biodiversity appears first as major ways of life (plankton, nekton, benthos and parasites), and secondly as large groups of species having different

temperature-controlled geographic distributions heavily influenced by the Earths evolutionary history. Ecosystems are a third kind of functional organization of microbial, plant and animal communities, heavily dependent on depth and light in the sea. Most knowledge of genetic biodiversity in the sea now applies to "useful" species. Grave signs of danger to marine biodiversity call for urgent collective and individual actions.

1. Four Kinds of Biodiversity on Our Planet

It has become usual among biologists to distinguish between three to five kinds of biodiversity. Here we stress the differences among four kinds.

1.1. Species Biodiversity

Species biodiversity is based on species as the major operational units of life, individuals of which can recognize and breed among themselves and then transmit their hereditary units and machinery to their offspring, and have done so for long - sometimes extremely long - periods in the geological or evolutionary past. Such biodiversity may also be called low-level taxonomic biodiversity, taxonomy being the science of describing and classifying all known species. Examples of well-known species on land are the lion, the sparrow, the house fly and Man; familiar marine species are the Atlantic cod, the blue whale and the blue mussel. Only those species which have been easily recognized by humans have received such names in living languages. Since the vast majority of the other species had never been named previously in the rise of science, all known species have received from biologists scientific names derived from Latin. For instance, the Atlantic cod is named *Gadus morhua* and the related haddock is named *Gadus aeglefinus*; the second name is that of the species and the first one that of the so-called "genus", which expresses close affinity, like the family name of humans.

Each species has its peculiar way of life, called ecological niche, well known only for a very small number of the millions of species on earth. There are many more species on land than in the oceans and fresh waters, as summarized below. Most terrestrial species - about 60 percent - are insects, spiders and other related and mostly very small animals called arthropods because they have jointed legs, plus a similarly segmented body and a horny external covering called a cuticle cut up into articulated or sutured plates.

1.2. High-level Taxonomic Biodiversity

High-level taxomic biodiversity refers to the progressively larger and nested groups of species which make up a hierarchical classification of living beings. The higher groups encompass or contain the lower groups, and differences in their characters are greater and more numerous between the higher-level groups than between those at lower levels. Species are thus grouped into genera (singular: genus), genera into families, families into orders, orders into classes, classes into phyla (singular: phylum) and phyla into kingdoms. Groups at all levels are called taxa (singular: taxon). Biologists formerly recognized only two kingdoms, plants and animals (plus the kingdom of lifeless rocks and minerals, now obsolete). With progress in knowledge at the microscopic and molecular levels, scientists now recognize five kingdoms, *animals* (many-celled and eating other living beings), *plants* (many-celled and capable of photosynthesizing their own organic matter), *fungi* (many- or single-celled decomposers of other living beings, and including mushrooms and yeasts), *protists* (mostly single-celled and working either as plants or animals) and *Monera* (mostly bacteria, still smaller single cells and chemical wizards); protists are in the process of being split into two respectable kingdoms, *Protozoa* (animal protists mostly) and *Chromista* (plant protists mostly), based on new ultramicroscopical and molecular discoveries. All this shows that high-level taxa depend on the advancement of specialized knowledge and on the educated opinion of those few biologists holding such knowledge. Although the species content of upper taxa is generally agreed upon, the name of a taxon and the level at which it is nested in the hierarchy is somewhat arbitrary: for instance, Table 1 lists 33 phyla of animals as of 1987, whereas Table 2, with only 23 phyla, integrates some 1998 proposals relegating former phyla to the level of classes. Examples of classes, in the phylum Chordata, are mammals, birds, reptiles, amphibians, and bony fishes.

Phyla Subphyla	**Marine**		**Freshwater**		**Terrestrial**		**Symbiotic**	
	Benthic	**Pelagic**	**Benthic**	**Pelagic**	**Moist**	**Xeric**	**Ecto**	**Endo**
Porifera	+++		+				+	
Placozoa	+							
Orthonectida								+
Dicyemida								+
Cnidaria	+++	++	+	+			+	
Ctenophora	+	+						
Platyhelminthes	+++	+	+++		++		+	++++
Gnathostomulida	++							
Nemertea	++	+	+		+		+	
Nematoda	+++		+++		+++	+	+++	+++
Nematomorpha		+	++					++
Acanthocephala								++
Rotifera	+	+	++	++	+		+	+
Gastrotricha	++		++					
Kinorhyncha	++							
Loricifera	+							
Tardigrada	+		++		+			
Priapula	+							
Mollusca	++++	+	+++		+++	+	+	+
Kamptozoa	+		+				+	
Pogonophora	++							
Sipuncula	++							
Echiura	++							
Annelida	++++	+	++		+++		++	
Onychophora					+			
Arthropoda								
Crustacea	++++	+++	+++	++	++		++	++
Chelicerata	++	+	++	++	++++	+++	++	+

Uniramia	+	+	+++	++	+++++	+++	++	++
Chaetognatha	+	+						
Phoronida	+							
Brachiopoda	++							
Bryozoa	+++		+					
Echinodermata	+++	+						
Hemichordata	+							
Chordata								
Urochordata	+++	+						
Cephalochordata	+							
Vertebrata	+++	+++	++	+++	+++	+++	+	+

«Pluses» indicate approximate abundance of living described species: + = 1-100; ++ = 100-1,000; +++ = 10^3 to 10^4; ++++ = 10^4 to 10^5; +++++ = 10^5 or greater.
«Xeric»: dry habitat; «Symbiotic»: living intimately with, outside («ecto») or within («endo») the body of other living organisms, often as parasites; «Benthic»: living in, on or close to the bottom; «Pelagic»: living in midwater, independently of the bottom.

Table 1. Species biodiversity of described adult animals in 33 phyla and subphyla from different habitats of the biosphere, expressed as orders of magnitude (modified from Pearse *et al.*, 1987. *Living invertebrates*. p. 7. Boxwood Press)

High-level taxonomic groups are essentially categories of species molded into their very distinctive and numerous differences by their intricate and stable heredity, acquired over the extremely long time of their evolution: they have gradually adapted to slowly changing environments, survived abrupt ecological catastrophes, and been locked into their distinctive morphological architecture. Choosing among marine examples, the huge architectural differences between animal phyla can be seen when comparing a sponge (phylum Porifera), a sea star (phylum Echinodermata), a lobster (phylum Arthropoda) and any fish (phylum Chordata). Dissection of individuals of such groups will reveal in their anatomy still more of their fundamental body-plan differences. Most phyla are very ancient, having originated prior to 600 million years ago, before most of the fossils were formed: they may thus be qualified as the memory of the biosphere. Very few phyla have disappeared since their origin, since this would have involved the very unlikely extinction of all their species everywhere, but very many species and genera, in different phyla and classes, have suffered extinction somewhere over these hundred million years.

1.3. Genetic Biodiversity

Genetic biodiversity underlies the two previous kinds of diversity, since the hereditary units called «genes» provide the basic unseen molecular mechanism producing the myriads of characters, seen and unseen, making up the different species. Genes are actually blocks of special chemicals grafted on a large helicoidal molecule common to all living organisms and called deoxyribonucleic acid (DNA). The chemical structure and function of this basic molecule and its satellite chemicals were only discovered after 1950. One gene may sometimes be responsible for a single character, but much more commonly gene combinations or genes turned on or off by other genes throughout development and growth are involved in the quite complex genetic machinery being unraveled through the major technological advances of recent decades. Some very conservative genes or gene combinations account for high-level taxonomic biodiversity, whereas error-prone (i.e., mutant) genes are responsible for species biodiversity, and even for variations within species. Such subspecific variation or biodiversity is essential for adaptive evolution in changing environments, but it also increases enormously the number of characters, now molecular in nature, to be considered by biologists in distinguishing species. Sibling species, for instance, are species which can only be recognized by their genetic differences, since their morphological characters are the same. But it can be predicted that they will prove to differ in behavior, in subtle physiological abilities (e.g., temperature tolerance or digestive power), in production of or resistance to various chemicals, or in other such properties not so easily observed as morphological characters.

-
-
-

Bibliography

American Institute of Biological Sciences. (1991). Marine biological diversity. *BioScience* **41(7)**, 453-509. AIBS, Washington, DC 20001-4521 [Special issue of ten papers by specialists, for the average biologist].

May R.M. (1994). Biological diversity: differences between land and sea. *Phil. Trans. Roy. Soc. Lond. (B)* **343**, 105-111 [Instructive comparative figures on specific and high-level taxa, and the interpretations of land-freshwater-sea differences].

Ormond R.F.G., Gage J.D., and Angel M.V. (eds). (1997). *Marine biodiversity: patterns and processes.* 449 pp. Cambridge Univ. Press, Cambridge, U.K. and New York, N.Y. [Eighteen excellent technical papers by specialists on various aspects of marine biodiversity].

Pearse V., Pearse J., Buchsbaum M., and R. Buchsbaum. (1987). *Living invertebrates*. 848 pp. Boxwood Press, Pacific Grove, CA and Blackwell Sci. Publ., Palo Alto, CA [A good popular presentation of the most numerous high-level taxa in the animal kingdom].

Reaka-Kudla M.L., Wilson D.E. and Wilson E.O. (eds). (1997). *Biodiversity II: understanding and protecting our biological resources.* 551 pp. Nat. Acad. Press, Washington, D.C. [A recent update by several leading authors, covers most ecosystems in the biosphere].

Sherman K. (1994). Sustainability, biomass yields, and health of coastal ecosystems: an ecological perspective. *Mar. Ecol. Progr. Ser.* **112**, 277-301 [A good summary on the 49 large marine coastal ecosystems of the world and their importance].

Sullivan K.D. (1996). Marine biological diversity. *Oceanography* **9(1)**, 1-103. (spec. ed.). Oceanography Society, Virginia Beach, VA 23455 [Special issue of 16 papers by specialists for the average marine scientist or educator].

Woods Hole Oceanographic Institution. (1995). Marine biodiversity I. *Oceanus* **38(2)**, 1-33. WHOI, Woods Hole, MA 02543 [Special issue of eight papers by specialists, for the average marine scientist or educator].

Woods Hole Oceanographic Institution. (1996). Marine biodiversity II. *Oceanus* **39(1)**, 1-18. WHOI, Woods Hole, MA 02543 [Continuation of previous special issue with eight more papers].

Biographical Sketch

Pierre Brunel, born in Montreal in 1931, obtained a B.Sc. in Biology from the Université de Montréal in 1952. His study of amphipod Crustacea in Baie des Chaleurs, started in 1954, led to an M.A. from the University of Toronto, then to employment by the Station de Biologie Marine de Grande-Rivière (Gaspé)(Quebec Department of Fisheries). In 1966 he moved to teaching in the Department of Biological Sciences of the Université de Montréal and obtained his Ph.D. in 1968 from McGill University. In 1970 he joined ex-colleagues from Grande-Rivièere and others from McGill to establish the Groupe Interuniversitaire de Recherches Océanographiques du Québec (GIROQ), where he sat on the executive board until 1989. His research has dealt mostly with the ecology of marine bottom communities, mostly in the Gulf and Estuary of the St.Lawrence, but also in the Saguenay Fjord, the Bay of Fundy, and Hudson Bay, as well as amphipod taxonomy and cod feeding and migrations. Since 1990 he has redirected his activities more toward biodiversity and saving research collections, especially through the establishment with colleagues of the Québec Biodiversity Network. He co-authored, in 1998 a critical and well-documented catalogue of the 2 214 species of marine invertebrates identified since 1841, from the Gulf of St.Lawrence.