

Evolution

The Species Concept

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Species is a Latin word meaning “kind” or “appearance”. We distinguish between various “kinds” of plants or animals – between dogs and cats, for instance – from differences in their appearance. But are organisms truly divided into the discrete units we call species, or is this classification an arbitrary attempt to impose order on the natural world? To answer this question, biologists have compared not only the morphology (body form) of different groups of organisms but also less obvious differences in physiology, biochemistry, and DNA sequences. The results generally confirm that morphologically distinct species are indeed discrete groups, with many differences in addition to morphological ones.

Systematists faced a tough challenge i.e. the classification of living organisms. In any case, classification is possible, because discontinuities do exist between different organisms. Shakespeare may have believed that what was there in a name? But nomenclature or classification is a necessity in evolution. A telephone directory would be worthless if it listed entries in random sequence without any order. Similarly in evolution, one needs to categorize the vast number and types of organisms in some sequence, since it's not possible to study each and every organism individually, in view of enormous biological diversity. Therefore, nomenclature is must. Thus, in order to understand the nature of evolutionary forces and their operation, it's necessary to classify the living organisms and the most prominent and popular category of classification is 'species'. Although this term has been in usage for a very long time, it is still surrounded with confusion and ambiguity. To the beginners, it can be introduced as a group of populations that form natural units or aggregates of similar individuals. It can also be designated as the most fundamental unit of taxonomy (biology evolution or some believed it to be lowest range in taxonomy). The main criteria for giving species status in taxonomy are convenience and workability in practical classification. It is traditional practice in taxonomy and also a requirement of the rules of nomenclature to classify all organisms into species, whether they are sexual, biparental or not. Baton said, “Though we can't strictly define species, they have properties which varieties don't have and distinction is not merely a matter of degree”. While, Tate Regan stated “A species is a community or a number of related communities whose distinctive morphological characteristics are, in the opinion of a competent systematist, sufficiently definite to entitle it or them, to a specific name”. For a very long time, even after the rediscovery of Mendelian principles, several geneticists believed it to be an “artificial grouping” or “man made categories of thought” with no constant characters. Linnaeus himself said this of higher categories, but species, he regarded as a real unit or thing with constant characteristics and sharp boundaries. Thus, there were many concepts prevalent about the term “species” which compelled Moody to comment that species is a definite but diversified phenomenon to be characterized rather than defined as a whole.

Species are a compromise between too much and too little adaptive conservatism and wasteful innovation. On one hand, species holds fast to genotypes, the adaptiveness of which has been tested by Natural Selection and found satisfactory in the existing environment. On the other hand, improvisation of new genotypes, “explores” field of possible newer gene combinations and may lead to “discovery” of unoccupied adaptive peaks. “Exploration” however also involves a “cost”. Novel gene combinations can sometimes may be inferior and can even endanger the continuation of populations.

The term, “Species” has been defined differently and independently by the various categories of scientists i.e. taxonomists, evolutionists, geneticists, biologists etc.

Some of the popular concepts about this term are listed below.

I. Morphological/Typological Species Concept

This concept was developed by taxonomists of 18th and 19th century; particularly Linnaeus for identification and description of shells or insects from preserved specimens. It was based mainly on morphological characteristics i.e. colour, texture of body, form, length, shape of reproductive organs etc. According to them, a morphological species was a morphologically distinct population of morphologically distinct organisms. Davis and Heywood defined it as “assemblages of individuals with morphological features in common and separable from other such assemblages by correlated morphological discontinuities in a number of features”.

But this concept was later rejected as it was misleading in cases of polymorphic diversity within a species and in cases where sympatric but unrelated species exhibit extreme morphological similarities. It was also arbitrary and relied heavily on the judgement of a competent taxonomist. Individuals were members of a given species if they sufficiently conformed to that “type” or ideal.

II. Numerical/Phenetic Species

To eliminate some arbitrary distinctions, another group of taxonomists viz. Sneath and Sokal, proposed numerical methods in which taxonomic distinctions depended on size of statistical correlation for as large number of characteristics as possible. These characteristics were all given equal numerical weight. A high statistical correlation among individuals for a large number of such characteristics viz. number of vertebrae, legs etc. indicated their membership in same species or groups whereas a low correlation points to their separation into different species or groups e.g. a wolf and a dog (same genus) look phenotypically more alike than do a wolf or dolphin (same class).

III. Biological Species Concept

This concept came into existence when the earlier concept was found to be wanting in some respects, particularly in objectivity. This concept was of special importance in nature and was observed everywhere in biotic communities and natural pools and was found to be closest to biological realities. It became very popular. Dobzhansky initially propounded it in 1937 and defined it as “the most inclusive mendelian population or largest reproductive community of sexual and cross-fertilizing individuals, which share a common gene pool.” However Mayr in 1942 proposed the most comprehensive definition of species, where he stated that “species are groups of actually or potentially interbreeding natural populations that are reproductively isolated from other such groups. He stressed on the following main characteristics:-

1. Species are defined by distinctness and not by differences.
2. Species consist of populations and not unconnected individuals.
3. The decisive factor is reproductive isolation. and
4. Species are a dynamic unit.

Therefore, according to the biological species concept, the critical factor determining the status of species was reproductive isolation. Populations could be considered as separate species only when they were unable to interbreed, whether they occurred in the same or in different regions or even if their areas of distribution overlapped. (From now onwards they pursued independent evolutionary paths and hence formed new species but prior to the establishment of reproductive isolation, they were regarded as sub-specific categories). In fact, sympatry is the natural test and best criterion for judging the species status. Biological species are polytypic.

Advantages and Limitations

This concept gained popularity among scientists and biologists and soon became the acceptable norm as it had a more objective approach and discarded the subjectivity of the earlier species concepts. Moreover, it also helped to explain debatable taxonomic situations, inherent in the morphological species concept and discontinued the use of “standards” introduced by taxonomists of the past.

However, the concept was not without its limitations and some of them are:

- 1 The concept cannot be applied to dead specimens and fossil populations by museum taxonomists and paleontologists.
- 2 It can also not be applied to asexual populations or parthenogenetic organisms, which were referred to as “paraspecies” by Mayr (1987) and “pseudospecies” by Ghiselin (1987).

According to Sonneborn, its use is limited to “sexually reproducing species”.

- 3 This concept was found to be wanting in populations manifesting “horizontal gene transfer”, i.e. the plasmid or virus, (bacteriophage) mediated gene transmission, which occurred among supposedly unrelated or very distantly related organisms e.g. *Escherichia* & *Salmonella* have similar genes and gene sequences indicating gene exchange.
- 4 It was non-dimensional and not applicable to allopatric and allochronous species.

Simpson in his book on “Systematic Biology” pointed out these drawbacks and proposed the concept of evolutionary species, which was advocated by Mayr and Dobzhansky also.

IV. Evolutionary Species or Successional Species Concept

It was a lineage (ancestor- descendant sequence of populations) evolving separately from others and with its own unitary evolutionary role and tendencies. It used ecological, behavioral, genetic and morphological evidence to help judge evolutionary separation or distance.

This concept avoided certain drawbacks of biological species concept and is equally applicable to asexual and sexual forms as well as fossil and extinct forms. However, it provides no means for distinguishing one evolutionary line from the other. It can distort phylogenetic relationships. Moreover, biologists did not agree on how to evaluate evolutionary distance and relate it to classification.

These species are considered to be nodal points in a phyletic evolutionary trend that differ enough from each other to be granted status of different species e.g. lineage of late Cenozoic

elephants consists of a pair of evolutionary species *Elephas planifrons* & *E. meridionalis*. Thus, evolutionary species are different from biological species in that they are the product of phyletic evolution rather than being based on criteria of reproductive isolation.

Some more species concepts:

- **Ecological species concept** – defines a species as a set of organisms adapted to a particular niche. Discontinuities in resources, such as in hosts of parasitic species and inter-specific competition can shape phenetic distribution of species into discrete clusters.
- **Ceno-Species** – A collective category including all eco-species that are sufficiently closely related to permit interbreeding to certain extent.
- **Micro-Species** – Uniparental organisms also form populations and colonies, which consist of genotypically identical or similar individuals occupying special habitat and making particular ecological demands on the environment. They are populations but not breeding populations. Biological species concept breaks down in such cases as also the taxonomic/morphological species; because variations formed are more or less continuous. Botanists who encounter this situation in several plants have coined this special term. Micro-species are genotypically similar populations or population systems with recognizable phenotypic characteristics of its own in uniparental system.
- **Semi-Species** – Intermediate stages of differentiation between distinct geographical races and allopatric species, between ecological races and sympatric species. These populations are connected by gene flow i.e. they are intermediate between races and species. Such borderline situations are bound to exist if the process of species formation is gradual rather than instantaneous. Mayr said that semi species show some characteristics of species and others of sub species.
- **Race** – It is a very often used term with wide application. For an anthropologist it is equivalent to populations of subspecies level of distinctness whereas others regard it as subdivision of subspecies.
- **Strains** – refer to a population from a particular geographical locality without any other characteristics of distinctness. Perhaps they are sub-species. Parasitologists and microbiologists find it invaluable in comparing lines derived from different host animals or plants. Virologists identify strains of disease producing forms by the name of the city, state or country where they were first identified.
- **Recognition species concept** – defines a species as set of organisms with shared specific mate recognition system. Different members of a species recognize one another as potential mates.
- **Clone** – useful in taxa that propagate asexually or vegetatively. This term is used frequently in microbiology and parasitology. It is a population produced by a single parent.
- **Sibling species:** Sympatric populations that are morphologically similar or almost identical but reproductively isolated. Also known as “biological races”.
- **Subspecies:** “Is an aggregate of phenotypically similar, geographically isolated local populations (demes) of a species, which inhabit a geographic subdivision of the range of species and differ genetically as well as morphologically from other populations of the species, but still *interbreed* or are capable of interbreeding and producing fertile hybrids” (Mayr). It is a taxonomic category lower than morphological species and is a

replacement for the term “variety”. In Zoology, it is equivalent to “geographic races” however in botany it may be sympatric forms. In recent literature, systematists have advised against the use of this term.

- *Superspecies*: Usually, the aggregate of a group of semispecies. Sometimes designates a group of closely related allopatric or nearly allopatric forms that are designated as different taxonomic species. The equivalent German term, is *Artenkreis* (Art = “Species Kreis = Circle” as in a “circle of friends”.)
- *Ring species*: A chain of interbreeding “races” or subspecies, the ends of which overlap but don’t interbreed, equals “circular overlap” (but not equivalent to “*Rassenkreis*”.)
- *Rassenkreis/Polytypic species*: A geographically variable species, usually divided into subspecies.
- *Clines*: Groups of local populations or demes of a widely distributed species, which exhibit regular and gradual step-wise modification from one part of their geographic range to another (Huxley). Such gradual changes in the morphology or continuous variations are due to intergradations of gene pools between local populations or demes.
- *Variety*: Non-genetic variants or heterogenous combination of a phenotype caused by climatic effects (Linnaeus) used in plant systematics, sometimes in the sense of ecotype (phenotypic variant of a species associated with particular type of habitat.)
- *Demes*: It is a community of potentially interbreeding individuals in a given locality, which share a common gene pool. It is considered to be the smallest taxonomic unit of locally breeding populations which is partially isolated, occupying an area where conditions are optimal and the size is highly variable.
- Isolation among demes doesn’t depend upon geographic isolation only but also on the habit of animals. Genetic differentiation appears in demes partly by mutation or recombination and rearrangement of genes. Differentiated demes are known as *micro-species* (Gilmour and Gregor).

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