

Rebase 2024 Year in review

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Update of Rebase 2024

In the year 2024, Rebase increased the number of entries by 10,197, including 9,668 sequences published on Rebase Reports. The total number of entries reached 102,832 at the end of the year 2024. The majority (101,248: 98.5%) of these entries are transposable elements (TEs), either consensus or representative sequences. The remaining are satellite repeats and microsatellites (599 entries), integrated viruses (227 entries), multicopy genes (199 entries) and uncharacterized repeats.

Rebase transitioned to a subscription-based model on April 12, 2019. The last version of Rebase before the transition was Rebase Update 24.03 which included 50,356 entries. Since then, we have (1) increased the number of repeats published in each issue of Rebase Reports, and (2) covered more diverse organisms (Table 1). The choice of organisms is based on (1) the economic and scientific importance, (2) the quality and the size of genome sequence, (3) the phylogenetic distance from well-analyzed organisms, and (4) the presence of new or unique groups of TEs. We have continually updated, classified, corrected, and refined existing repeats that contain sequence flaws or are ambiguously classified.

Rebase has been expanding to be a large dataset covering various eukaryotic repeats. The three major phylogenetic groups of Rebase entries are vertebrates, arthropods, and green plants (Figure 1). Vertebrate includes humans, lab animals, and almost all domestic or farmed animals for meat, labor/transportation, and pets (cow, sheep, goat, pig, camel, llama, horse, cat, dog, Guinea pig, mice, hamsters, rabbits, chicken, duck, goldfish, carp, salmon, tilapia, catfish, etc.). Major crops are classified into only a few orders in green plants: Poales (wheat, barley, rye, oat, maize, sorghum, millets, sugarcane, rice), Brassicales (cabbage/kale/broccoli, Chinese cabbage, radish), Fabales (pea, common bean, soybean, peanut, chickpea, alfalfa), Rosales (apple, pear, cherry, plum, strawberry), and Solanales (potato, tomato, tobacco, sweet potato).

Arthropod is the largest group of animals and counts for >80% of all living animal species. Arthropod includes a vast majority of pests for humans and domestic animals (mosquitoes, flies, flea, bugs, lice, ticks, etc.), and for crops (caterpillars, flies, sawflies, leaf beetles, aphids, whiteflies, locusts, etc.). Other noticeable groups are mollusks (including oyster, mussel, clam, and abalone), fungi (including yeasts, edible mushrooms, and plant pathogens such as *Puccinia* and *Blumeria*), and stramenopiles (including plant pathogens such as *Phytophthora*).

At the end of the year 2024, Repbase contains repeat sequences from over 2,000 species. Six TE-rich species (yellow fever mosquito, Asian rice, zebrafish, African clawed frog, maize, and Pacific oyster) each have over 2,000 entries (Table 2). Sometimes, multiple genomes in the same genus, such as *Drosophila* and *Arabidopsis*, have been sequenced and analyzed. Such analysis helps characterize very low-copy TE families or single-copy TE families in model organisms and reveals the genome evolution over a longer time scale. Table 3 shows the total number of Repbase entries for each genus. In some cases, such as *Chondrus* and *Locusta*, only one species has been analyzed, while in other cases, such as *Drosophila*, more than 2 species have been examined (Table 4). Table 5 shows the top 30 species whose entries increased in the year 2024. Even though the genomes of model organisms are very well analyzed, they still contain TE families to be discovered. It is challenging to assert that all TEs, regardless of their age, have been identified within a single species. However, it is our ongoing goal to consistently assemble an expanding, and near-complete set of TEs in some crucial genomes. All organisms with over 100 Repbase entries are listed in Table 6.

The characteristics of several species we focused on in the year 2024 are described below.

Xenopus laevis (African clawed frog)

The African clawed frog (*Xenopus laevis*) is a species of African aquatic frog of the family Pipidae. *X. laevis* has been an essential model organism in the study of vertebrate embryology and development. *X. laevis* is an allotetraploid, likely originated by the hybridization of two related species happened around 17-18 million years ago. The tetraploidation occurred after its split from *Xenopus tropicalis*. Repbase now contains 2,281 entries from *X. laevis* and 766 from *X. tropicalis*.

Chionoecetes opilio (snow crab)

Chionoecetes opilio is a species of snow crab, native to the northwest Atlantic Ocean and north Pacific Ocean. *C. opilio* and related species are fished for culinary use; *C. opilio* is one of the most fished crabs in the world along with blue swimming crab (*Portunus pelagicus*) and red king crab (*Paralithodes camtschaticus*). The order Decapoda includes shrimps, prawns, crabs, and hermit crabs. Two shrimp species analyzed before, *Penaeus monodon* and *Penaeus (Litopenaeus) vannamei*, belong to the suborder Dendrobranchiata, different from the suborder Pleocyemata which *C. opilio* belongs to.

Amphibalanus amphitrite (striped barnacle)

Amphibalanus amphitrite is a species of acorn barnacle in the Balanidae family. It is one of the most widely distributed barnacle species, due to its fouling on ships. Biofouling by barnacles increases drag on ships, which leads to higher fuel consumption and cleaning costs. Phylogenetically barnacles (Cirripedia) are the members of Thecostraca, under Hexanauplia, which includes copepods. Currently Replibase contains 404 entries from *A. amphitrite*.

Anthonomus grandis (boll weevil)

The boll weevil, *Anthonomus grandis*, is native to Mexico and Central America but spread into the United States in the late 19th century, causing destructive effects on the cotton industry. It feeds cotton bulbs and flowers, and lays its eggs inside the cotton bolls (fruit of the cotton plant), where the larvae develop. *A. grandis* is considered one of the most devastating pests in cotton agriculture. *A. grandis* and the rice weevil *Sitophilus oryzae* are in the same family Curculionidae. Replibase now contains 430 entries from *A. grandis* and 188 from *S. oryzae*. Other than these two species, noticeable coleopteran insects in Replibase are *Rhyzopertha dominica* (513 entries, Bostrichidae), *Photinus pyralis* (202 entries, Lampyridae), and *Tribolium castaneum* (88 entries, Tenebrionidae).

Drosophila (fruit flies)

The genus *Drosophila* contains over 1,450 species, among which ~1,100 species belong to the subgenus *Drosophila*. *D. melanogaster* belongs to the subgenus *Sophophora*. In the year 2024, 145 TE families from the genus *Drosophila* were added to Replibase (Table 4). In total, Replibase contains 4,844 repeat entries from *Drosophila*.

Puccinia and relatives

All species in the genus *Puccinia* are obligate plant pathogens and are known as rusts. The genus *Puccinia*, which contains ~4,000 species, is considered the most economically destructive genus of biotrophic fungi; members of this genus are serious pathogens on all major cereal crop species except rice. The order Pucciniales includes additional ~3,000 species of rust fungi. Some of common rust fungi in agriculture are *Cronartium ribicola* (white pine blister rust), *Gymnosporangium juniperi-virginianae* (cedar-apple rust), *Hemileia vastatrix* (coffee leaf rust), *Phakopsora pachyrhizi* (Asian soybean rust), and *Uromyces appendiculatus* (bean rust). The number of Rebase entries from each species is shown in Table 7.

Triticum aestivum (bread wheat)

Wheat is one of the most important staple crops globally. It is a major ingredient in bread, pasta, cereals, and cakes. Alcoholic beverages such as beer (although the primary grain used in most traditional beer styles is barley) and vodka are also made from wheat. The bread wheat (common wheat) *Triticum aestivum* is believed to have originated from the hybridization of two wild grass species in the Fertile Crescent, a region in the Middle East. The two ancestral grass species are likely the emmer wheat *Triticum dicoccum* and the wild goatgrass *Aegilops tauschii*. In the year 2024, the entries from *T. aestivum* increased by 648, and the total number of entries became 1,792. In addition to the bread wheat, several other wheat species are also cultivated: durum wheat *T. durum*, spelt *T. spelta*, emmer wheat *T. dicoccum*, and einkorn wheat *T. monococcum*. Rebase contains 8 sequences from *T. durum*, 1 from *T. spelta*, 67 from *T. monococcum*, as well as 8 sequences from *Aegilops tauschii*.

Raphanus sativus (radish)

Raphanus sativus, commonly known as the radish, is an edible root vegetable of the Brassicaceae family, which also includes cabbage and *Arabidopsis thaliana*. Originally domesticated in Asia, radishes are now grown and consumed throughout the world. Currently Rebase contains 653 entries from *R. sativus*.

TE classification

The number of Rebase entries in each TE category is shown in Table 8, accompanied by the increase in the number of entries in the last three years. The increase of unclassified LTR retrotransposons is mostly due to the submission of 411 *Helenuis* families (Kojima 2024), a type of non-autonomous LTR retrotransposons. The increases in *Neptune*, *L1*, and *Academ* are mainly caused by the abundance of these transposons in the genome of *Xenopus laevis*.

As seen in Figure 2, more than half of Repbase entries belong to LTR retrotransposon including endogenous retroviruses (ERVs), and a quarter to the *Gypsy* superfamily. In the current classification scheme of non-LTR retrotransposons, *LI* is the dominant, owing to the large number of *LI* families in mammals and land plants. The most dominant 6 superfamilies (*hAT*, *Mariner/Tc1*, *MuDR*, *Harbinger*, *Helitron*, and *EnSpm/CACTA*) sum up to around three-quarters (19,559) of total entries of DNA transposons.

References

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Helenus and *Ajax*, two groups of non-autonomous LTR retrotransposons, represent a new type of small RNA gene-derived mobile elements.

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Table 1. Organisms whose repeats were published in Rebase Reports in 2024.

Chordata	
- Vertebrata	
-- Amphibia	
-- Actinopterygii	<i>Bufo bufo</i> (common toad), <i>Xenopus laevis</i> (African clawed frog)
	<i>Barbus barbus</i> (common barbel), <i>Corythoichthys intestinalis</i> (scribbled pipefish), <i>Cynoglossus semilaevis</i> (tongue sole), <i>Mastacembelus armatus</i> (zig-zag eel), <i>Oryzias javanicus</i> (Javanese ricefish), <i>Oryzias latipes</i> (medaka), <i>Salarias fasciatus</i> (jewelled blenny), <i>Sphaeramia orbicularis</i> (orbiculate cardinalfish), <i>Trematomus loennbergii</i> (scaly rockcod), <i>Xenentodon cancila</i> (freshwater garfish)
Arthropoda	
- Insecta/Diptera	<i>Bibio marci</i> (St. Mark's fly), <i>Drosophila suzukii</i> (fruit fly), <i>Hermetia illucens</i> (black soldier fly), <i>Sitodiplosis mosellana</i> (orange wheat blossom midge)
- Insecta/Lepidoptera	<i>Aricia agestis</i> (brown argus), <i>Bombyx mori</i> (domestic silkworm), <i>Carcina quercana</i> (oak longhorn), <i>Colias croceus</i> (clouded yellow), <i>Deilephila porcellus</i> (small elephant hawk-moth), <i>Dendrolimus punctatus</i> (masson pine moth), <i>Endotricha flammealis</i> (rose-flounced tabby), <i>Hedya salicella</i> , <i>Helicoverpa armigera</i> (cotton bollworm), <i>Hyposmocoma kahamanao</i> , <i>Neomicropteryx cornuta</i> , <i>Plodia interpunctella</i> (Indianmeal moth), <i>Synanthedon vespiformis</i> (yellow-legged clearwing)
- Insecta/Coleoptera	<i>Anthonomus grandis</i> (boll weevil), <i>Photinus pyralis</i> (common eastern firefly), <i>Pterostichus madidus</i> (black clock beetle),
- Insecta/Neuroptera	<i>Chrysoperla carnea</i> ,
- Insecta/Hemiptera	<i>Ericerus pela</i> (Chinese white wax scale insect), <i>Neoaliturus tenellus</i> (beet leafhopper), <i>Nilaparvata lugens</i> (brown planthopper), <i>Sitobion miscanthi</i> (Indian grain aphid)
- Insecta/Odonata	<i>Platynemesis pennipes</i> (white-legged damselfly)
- Collembola/Symphyleona	<i>Allacma fusca</i> (springtail)
- Malacostraca/Decapoda	<i>Litopenaeus vannamei</i> (whiteleg shrimp), <i>Chionoecetes opilio</i> (snow crab)
- Thecostraca/Balanomorpha	<i>Amphibalanus amphitrite</i> (barnacle)
- Diplopoda/Spirobolida	<i>Trigoniulus corallinus</i> (rusty millipede)
- Arachnida/Ixodida	<i>Dermacentor silvarum</i> , <i>Haemaphysalis longicornis</i> (longhorned tick), <i>Rhipicephalus sanguineus</i> (brown dog tick)
Nematoda	
	<i>Angiostrongylus vasorum</i> , <i>Ascaris suum</i> (pig roundworm), <i>Haemonchus contortus</i> (barber pole worm), <i>Heterorhabditis bacteriophora</i> , <i>Necator americanus</i> , <i>Nippostrongylus brasiliensis</i> , <i>Parelaphostrongylus tenuis</i> , <i>Pristionchus pacificus</i> , <i>Trichostrongylus colubriformis</i> , <i>Crassostrea gigas</i> (Pacific oyster), <i>Sinonovacula constricta</i> (Chinese razor clam)
Mollusca	
Nemertea	
Cnidaria	
	<i>Telmatactis stephensoni</i> (sea anemone), <i>Dendronephthya gigantea</i> (soft coral)
Fungi	
Ascomycota	<i>Kalaharituber pfeilii</i> , <i>Peziza echinospora</i>
Basidiomycota	<i>Austropuccinia psidii</i> (myrtle rust), <i>Hemileia vastatrix</i> (coffee leaf rust), <i>Melampsora americana</i> (rust), <i>Phakopsora pachyrhizi</i> (Asian soybean rust), <i>Puccinia graminis</i> (wheat stem rust), <i>Puccinia triticina</i> (wheat leaf rust)
Angiospermae	
- Monocots	
-- Poales	<i>Hordeum vulgare</i> (domesticated barley), <i>Triticum aestivum</i> (bread wheat), <i>Zea mays</i> (maize)
- Asterids	
-- Apiales	<i>Daucus carota</i> (carrot)
-- Aquifoliales	<i>Ilex paraguariensis</i> (yerba mate)
- Rosids	
-- Fabales	<i>Arachis duranensis</i> (peanut), <i>Vigna radiata</i> (mung bean)
-- Fagales	<i>Juglans regia</i> (Persian walnut)
-- Malpighiales	<i>Manihot esculenta</i> (cassava)
-- Rosales	<i>Ficus carica</i> (fig), <i>Prunus persica</i> (peach), <i>Pyrus betulifolia</i> (birchleaf pear), <i>Ziziphus jujuba</i> (common jujube)
-- Sapindales	<i>Citrus sinensis</i> (sweet orange)
-- Myrtales	<i>Eucalyptus camaldulensis</i> (Murrey red gum), <i>Punica granatum</i> (pomegranate)
-- Brassicales	<i>Raphanus sativus</i> (radish)
-- Cucurbitales	<i>Cucumis melo</i> (muskmelon)
- Magnoliids	
-- Laurales	<i>Persea americana</i> (avocado)

Table 2. Top 40 species based on the number of Rebase entries.

Species	Total	2024 Increase
<i>Aedes aegypti</i> (yellow fever mosquito)	3648	0
<i>Oryza sativa</i> (Asian rice)	3438	-1
<i>Danio rerio</i> (zebrafish)	2473	0
<i>Xenopus laevis</i> (African clawed frog)	2281	1948
<i>Zea mays</i> (maize)	2115	7
<i>Crassostrea gigas</i> (Pacific oyster)	2013	191
<i>Triticum aestivum</i> (bread wheat)	1792	648
<i>Arabidopsis lyrata</i> (lyrate rockcress)	1567	0
<i>Chondrus crispus</i> (Irish moss)	1185	0
<i>Arabidopsis thaliana</i> (thale cress)	1136	0
<i>Locusta migratoria</i> (migratory locust)	1129	0
<i>Hydra vulgaris</i> (hydra)	1003	0
<i>Medicago truncatula</i> (barrel medic)	1001	0
<i>Sorghum bicolor</i> (sorghum)	979	0
<i>Chrysemys picta bellii</i> (painted turtle)	843	0
<i>Drosophila takahashii</i> (fruit fly)	821	0
<i>Xenopus tropicalis</i> (western clawed frog)	766	0
<i>Corbicula fluminea</i> (Asian clam)	764	0
<i>Nematostella vectensis</i> (starlet sea anemone)	757	0
<i>Chionoecetes opilio</i> (snow crab)	741	741
<i>Culex quinquefasciatus</i> (southern house mosquito)	660	0
<i>Lepeophtheirus salmonis</i> (salmon louse)	654	0
<i>Raphanus sativus</i> (radish)	653	116
<i>Drosophila willistoni</i> (fruit fly)	637	0
<i>Carassius auratus</i> (goldfish)	633	1
<i>Homo sapiens</i> (human)	584	0
<i>Glycine max</i> (soybean)	578	0
<i>Salmo salar</i> (Atlantic salmon)	535	0
<i>Malus domestica</i> (apple)	526	0
<i>Rhyzopertha dominica</i> (lesser grain borer)	513	0
<i>Alligator mississippiensis</i> (American alligator)	508	0
<i>Melampsora larici-populina</i> (poplar leaf rust fungus)	507	7
<i>Puccinia triticina</i> (wheat leaf rust)	506	196
<i>Solanum tuberosum</i> (potato)	486	0
<i>Litopenaeus (Penaeus) vannamei</i> (whiteleg shrimp)	479	38
<i>Amblyraja radiata</i> (thorny skate)	467	0
<i>Phytophthora infestans</i>	465	0
<i>Mus musculus</i> (domestic mouse)	464	0
<i>Haemophysalis longicornis</i> (Asian longhorned tick)	464	198
<i>Penaeus monodon</i> (Asian tiger shrimp)	452	0

Table 3. Top 30 genera based on the number of Rebase entries.

Genus (Species with >10 entries)	Total	2024 Increase
<i>Drosophila</i> ¹	4844	145
<i>Aedes</i> (<i>A. aegypti</i>)	3649	0
<i>Oryza</i> (<i>O. sativa</i>)	3455	-1
<i>Xenopus</i> (<i>X. laevis</i> , <i>X. tropicalis</i>)	3051	1949
<i>Arabidopsis</i> (<i>A. thaliana</i> , <i>A. lyrata</i>)	2703	0
<i>Danio</i> (<i>D. rerio</i>)	2487	0
<i>Crassostrea</i> (<i>C. gigas</i> , <i>C. virginica</i>)	2207	203
<i>Zea</i> (<i>Z. mays</i>)	2115	5
<i>Puccinia</i> (<i>P. striiformis</i> , <i>P. graminis</i> , <i>P. hordei</i> , <i>P. triticina</i> , <i>P. coronata</i> , <i>P. horiana</i>)	2057	697
<i>Triticum</i> (<i>T. aestivum</i> , <i>T. monococcum</i>)	1874	648
<i>Chondrus</i> (<i>C. crispus</i>)	1185	0
<i>Locusta</i> (<i>L. migratoria</i>)	1129	0
<i>Medicago</i> (<i>M. truncatula</i>)	1010	0
<i>Hydra</i> (<i>H. vulgaris</i>)	1003	0
<i>Sorghum</i> (<i>S. bicolor</i>)	979	0
<i>Panaeus</i> (<i>P. monodon</i> , <i>P. (Litopanaeus) vanna</i>)	931	38
<i>Anopheles</i> (<i>A. gambiae</i> , <i>A. funestus</i> , <i>A. merus</i> , <i>A. stephensi</i>)	885	-1
<i>Chrysemys</i> (<i>C. picta</i>)	843	0
<i>Phytophthora</i> (<i>P. infestans</i> , <i>P. sojae</i> , <i>P. ramorum</i> , <i>P.</i> <i>parasitica</i>)	791	0
<i>Corbicula</i> (<i>C. fluminea</i>)	764	0
<i>Nematostella</i> (<i>N. vectensis</i>)	758	0
<i>Chionoecetes</i> (<i>C. opilio</i>)	741	741
<i>Culex</i> (<i>C. quinquefasciatus</i>)	669	0
<i>Lepeophtheirus</i> (<i>L. salmonis</i>)	654	0
<i>Raphanus</i> (<i>R. sativus</i>)	653	116
<i>Mus</i> (<i>M. musculus</i> , <i>M. pahari</i> , <i>M. caroli</i> , <i>M. spretus</i>)	637	0
<i>Carassius</i> (<i>C. auratus</i>)	633	1
<i>Homo</i> (<i>H. sapiens</i>)	584	0
<i>Solanum</i> (<i>S. tuberosum</i> , <i>S. lycopersicum</i> , <i>S. demissum</i>)	582	0
<i>Glycine</i> (<i>G. max</i>)	578	0

¹ Species are shown in Table 4.

Table 4. Repbase entries from the genus *Drosophila*.

Subgenus - Group (subgroup)	Species	Abbr.	Repbase entries	2024 Increase
<i>Sophophora - melanogaster</i> (<i>melanogaster</i> subgroup)	<i>D. melanogaster</i>	DM	296	0
	<i>D. simulans</i>	DSim	43	0
	<i>D. sechellia</i>	DSe	33	0
	<i>D. yakuba</i>	DY	139	0
	<i>D. erecta</i>	DEre	18	0
(<i>suzukii</i> subgroup)	<i>D. suzukii</i>	DSuz	352	145
	<i>D. biarmipes</i>	DBi	80	0
(<i>ananassae</i> subgroup)	<i>D. ananassae</i>	DAn	240	0
	<i>D. bipectinata</i>	DBp	158	0
(<i>elegans</i> subgroup)	<i>D. elegans</i>	DEl	314	0
(<i>takahashii</i> subgroup)	<i>D. takahashii</i>	DTa	821	0
(<i>rhopaloa</i> subgroup)	<i>D. rhopaloa</i>	DRh	116	0
(<i>montium</i> subgroup)	<i>D. kikkawai</i>	DKi	97	0
	<i>D. serrata</i>	DSer	71	0
<i>Sophophora - ficusphila</i>	<i>D. ficusphila</i>	DF	129	0
<i>Sophophora - eugracilis</i>	<i>D. eugracilis</i>	DEu	200	0
<i>Sophophora - obscura</i>	<i>D. azteca</i>	DAzt	102	0
	<i>D. pseudoobscura</i>	DPse	80	0
	<i>D. persimilis</i>	DPer	106	0
<i>Sophophora - willistoni</i>	<i>D. willistoni</i>	DWil	637	0
<i>Drosophila - immigrans</i>	<i>D. albomicans</i>	DAlb	254	0
<i>Siphlodora - repleta</i>	<i>D. mojavensis</i>	DMoj	235	0
	<i>D. hydei</i>	DHyd	39	0
<i>Siphlodora - virilis</i>	<i>D. virilis</i>	DVi	148	0
<i>Idiomyia</i>	<i>D. grimshawi</i>	DGri	65	0

¹ Only species with >10 entries are shown.

² Subgroups are shown only in the *melanogaster* group.

Table 5. Top 30 species whose entries increased in 2024.

Species	2024 Increase	Total
<i>Xenopus laevis</i> (African clawed frog)	1948	2281
<i>Chionoecetes opilio</i> (snow crab)	741	741
<i>Triticum aestivum</i> (bread wheat)	648	1792
<i>Anthonomus grandis</i> (boll weevil)	430	430
<i>Austropuccinia psidii</i> (myrtle rust)	232	232
<i>Puccinia triticina</i> (wheat leaf rust, or brown rust)	219	506
<i>Dendrolimus punctatus</i> (masson pine moth)	217	217
<i>Haemaphysalis longicornis</i> (Asian longhorned tick)	198	464
<i>Phakopsora pachyrhizi</i> (Asian soybean rust)	195	195
<i>Crassostrea gigas</i> (Pacific oyster)	191	2013
<i>Hedya salicella</i> (tortrix moth)	182	184
<i>Salarias fasciatus</i> (jewelled blenny)	181	181
<i>Hemileia vastatrix</i> (coffee leaf rust)	172	172
<i>Amphibalanus amphitrite</i> (barnacle)	163	404
<i>Photinus pyralis</i> (common eastern firefly)	160	202
<i>Corythoichthys intestinalis</i> (scribbled pipefish)	154	154
<i>Zygaena filipendulae</i> (six-spot burnet)	146	148
<i>Drosophila suzukii</i> (fruit fly)	145	352
<i>Bufo bufo</i> (common toad)	122	209
<i>Puccinia coronata</i> (barley crown rust)	121	296
<i>Allacma fusca</i> (springtail)	120	285
<i>Raphanus sativus</i> (radish)	116	653
<i>Endotricha flammealis</i> (rose-flounced tabby)	110	114
<i>Oryzias javanicus</i> (Javanese ricefish)	109	114
<i>Neoliturus tenellus</i> (beet leafhopper)	100	100
<i>Telmatactis stephensoni</i> (sea anemone)	100	100
<i>Barbus barbus</i> (common barbel)	96	96
<i>Platycnemis pennipes</i> (white-legged damselfly)	94	94
<i>Xenentodon cancila</i> (freshwater garfish)	94	94
<i>Sinonovacula constricta</i> (Chinese razor clam)	91	100

Table 6. Phylogenetic distributions of organisms with >100 Repbase entries. Vertebrates, arthropods, fungi, and green plants are shaded in yellow, grey, purple, and green, respectively.

Phylum	Class	Order	Family	Species	Entries																																																																																																																																																																																																																																																																																		
Chordata	Mammalia			"Mammalia"	173																																																																																																																																																																																																																																																																																		
					Primates		"Eutheria"	229																																																																																																																																																																																																																																																																															
									Homidae	"Primates"	126																																																																																																																																																																																																																																																																												
												Cheirogaleidae	<i>Homo sapiens</i>	584																																																																																																																																																																																																																																																																									
															Galagidae	<i>Microcebus murinus</i>	122																																																																																																																																																																																																																																																																						
																		Tupaiaidae	<i>Otolemur garnettii</i>	119																																																																																																																																																																																																																																																																			
																				Scandentia		<i>Tupaia belangeri</i>	114																																																																																																																																																																																																																																																																
																							Rodentia		"Muridae"	101																																																																																																																																																																																																																																																													
																												"Mus"	48																																																																																																																																																																																																																																																										
																															<i>Mus musculus</i>	464																																																																																																																																																																																																																																																							
																																		"Rattus"	100																																																																																																																																																																																																																																																				
																																					<i>Rattus norvegicus</i>	115																																																																																																																																																																																																																																																	
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																																																																																																																																																																																																																																																																																		<i>Drosophila melanogaster</i>	296				
																																																																																																																																																																																																																																																																																						<i>Drosophila yakuba</i>	139

				<i>Drosophila suzukii</i>	352
				<i>Drosophila ananassae</i>	240
				<i>Drosophila bipectinata</i>	158
				<i>Drosophila elegans</i>	314
				<i>Drosophila takahashii</i>	821
				<i>Drosophila rhopaloa</i>	116
				<i>Drosophila ficusphila</i>	129
				<i>Drosophila eugracilis</i>	200
				<i>Drosophila azteca</i>	102
				<i>Drosophila persimilis</i>	106
				<i>Drosophila willistoni</i>	637
				<i>Drosophila albomicans</i>	254
				<i>Drosophila mojavensis</i>	234
				<i>Drosophila virilis</i>	148
			Culicidae	<i>Aedes aegypti</i>	3648
				<i>Culex quinquefasciatus</i>	660
				<i>Anopheles gambiae</i>	379
				<i>Anopheles funestus</i>	340
		Lepidoptera	Tortricidae	<i>Cydia splendana</i>	349
				<i>Hedya salicella</i>	184
			Zygaenidae	<i>Zygaena filipendulae</i>	148
			Papilionidae	<i>Papilio polytes</i>	181
			Nymphalidae	<i>Heliconius melpomene</i>	268
			Pyralidae	<i>Endotricha flammealis</i>	114
			Drepanidae	<i>Habrosyne pyritoides</i>	143
			Lasiocampidae	<i>Dendrolimus punctatus</i>	217
			Bombycidae	<i>Bombyx mori</i>	185
			Sphingidae	<i>Manduca sexta</i>	126
			Noctuidae	<i>Trichoplusia ni</i>	137
				<i>Spodoptera exigua</i>	223
				<i>Helicoverpa armigera</i>	173
			Lymantriidae/Erebidae	<i>Lymantria dispar</i>	114
		Coleoptera	Lampyridae	<i>Photinus pyralis</i>	202
			Bostrichidae	<i>Rhyzopertha dominica</i>	513
			Curculionidae	<i>Sitophilus oryzae</i>	188
				<i>Anthonomus grandis</i>	430
		Hymenoptera	Formicidae	<i>Solenopsis invicta</i>	248
				<i>Pogonomyrmex barbatus</i>	151
				<i>Monomorium pharaonis</i>	136
				<i>Camponotus floridanus</i>	101
				<i>Harpegnathos saltator</i>	193
				<i>Linepithema humile</i>	147
			Pteromalidae	<i>Nasonia vitripennis</i>	236
		Hemiptera	Cicadellidae	<i>Neoliturus tenellus</i>	100
			Aleyrodidae	<i>Bemisia tabaci</i>	336
				<i>Trialeurodes vaporariorum</i>	228
			Reduviidae	<i>Rhodnius prolixus</i>	296
			Aphididae	<i>Acyrtosiphon pisum</i>	346
		Orthoptera	Acrididae	<i>Locusta migratoria</i>	1129
	Collembola	Entomobryomorpha	Isotomidae	<i>Folsomia candida</i>	114
			Entomobryidae	<i>Sinella curviseta</i>	174
		Symphyleona	Sminthurididae	<i>Allacma fusca</i>	285
	Copepoda	Siphonostomatoida	Caligidae	<i>Lepeophtheirus salmonis</i>	654
				<i>Caligus rogercresseyi</i>	104
	Branchiopoda	Anomopoda	Daphniidae	<i>Daphnia pulex</i>	238
	Thecostraca	Balanomorpha	Balanidae	<i>Amphibalanus amphitrite</i>	404
			Sacculinidae	<i>Sacculina carcini</i>	161
	Malacostraca	Amphipoda	Hyalidae	<i>Parhyale hawaiensis</i>	151
		Decapoda	Penaeidae	<i>Penaeus monodon</i>	452
				<i>Penaeus vannamei</i>	479
			Oregoniidae	<i>Chionoecetes opilio</i>	741
	Arachnida	Ixodida	Ixodidae	<i>Haemaphysalis longicornis</i>	464
				<i>Hyalomma asiaticum</i>	107
				<i>Dermacentor silvarum</i>	121
Nematoda	Chromadorea	Rhabditida	Rhabditidae	<i>Caenorhabditis elegans</i>	183
				<i>Caenorhabditis briggsae</i>	231
Mollusca	Bivalvia	Ostreida	Ostreidae	<i>Crassostrea gigas</i>	2013
				<i>Crassostrea virginica</i>	192
				<i>Saccostrea glomerata</i>	198
		Arcida	Arcidae	<i>Tegillarca granosa</i>	108
		Venerida	Veneridae	<i>Cyclina sinensis</i>	182
				<i>Mercenaria mercenaria</i>	210
			Cyrenidae	<i>Corbicula fluminea</i>	764
		Cardiida	Solecurtidae	<i>Sinonovacula constricta</i>	100
	Gastropoda		Lottiidae	<i>Lottia gigantea</i>	120
Annelida		Canalipalata	Oweniidae	<i>Owenia fusiformis</i>	218
			Capitellidae	<i>Capitella teleta</i>	216
		Rhynchobdellida	Glossiphoniidae	<i>Helobdella robusta</i>	227
Nemertea	Clitellata	Heteronemertea	Lineidae	<i>Lineus longissimus</i>	231
	Pilidiophora			<i>Notospermus geniculatus</i>	121
Platyhelminthes		Tricladida	Dugesidae	<i>Schmidtea mediterranea</i>	396
Cnidaria	Hydrozoa	Anthoathecata	Hydridae	<i>Hydra vulgaris</i>	1003
	Hexacorallia	Actiniaria	Edwardsiidae	<i>Nematostella vectensis</i>	757
			Isophelliidae	<i>Telmatactis stephensoni</i>	100
		Scleractinia	Acroporidae	<i>Acropora digitifera</i>	257
	Octocorallia	Alcyonacea	Nephtheidae	<i>Dendronephthya gigantea</i>	123
Ascomycota	Leotiomycetes	Erysiphales	Erysiphaceae	<i>Blumeria hordei DH14</i>	257

Basidiomycota	Pezizomycetes Pucciniomycetes	Pezizales Pucciniales	Tuberaceae Pucciniaceae	<i>Blumeria graminis</i>	185			
				<i>Erysiphe pisi</i>	111			
				<i>Podosphaera xanthii</i>	127			
				<i>Choiromyces venosus</i>	100			
				<i>Puccinia graminis</i>	340			
				<i>Puccinia hordei</i>	303			
	<i>Puccinia triticina</i>	506						
	<i>Puccinia striiformis</i>	303						
	<i>Puccinia coronata</i>	296						
	<i>Melampsora larici-populina</i>	507						
	<i>Austropuccinia psidii</i>	232						
	<i>Hemileia vastatrix</i>	172						
	<i>Phakopsora pachyrhizi</i>	195						
	<i>Agaricus bisporus</i>	249						
Streptophyta	Agaricomycetes	Agaricales	Agaricaceae	<i>Oryza sativa</i>	3438			
				<i>Triticum aestivum</i>	1792			
	Poales	Poaceae	<i>Hordeum vulgare</i>	166				
			<i>Brachypodium distachyon</i>	282				
			<i>Zea mays</i>	2115				
			<i>Sorghum bicolor</i>	979				
			<i>Saccharum hybrid cultivar</i>	360				
			<i>Panicum miliaceum</i>	207				
			<i>Echinochloa crus-galli</i>	174				
			<i>Setaria italica</i>	149				
			Zingiberales	Musaceae	<i>Musa acuminata</i>	198		
					Vitales	Vitaceae	<i>Vitis vinifera</i>	362
							Fabales	Fabaceae
				<i>Arachis ipaensis</i>	208			
				<i>Arachis hypogaea</i>	122			
				<i>Medicago truncatula</i>	1001			
			Rosales	Rosaceae	<i>Malus domestica</i>	526		
					<i>Pyrus x bretschneideri</i>	156		
					<i>Prunus persica</i>	211		
				<i>Fragaria vesca</i>	265			
				Moraceae	<i>Morus notabilis</i>	332		
	Cannabaceae	<i>Cannabis sativa</i>	128					
		Malpighiales	Euphorbiaceae	<i>Ricinus communis</i>	185			
	<i>Jatropha curcas</i>			180				
	<i>Populus trichocarpa</i>			328				
	Malvales	Salicaceae	<i>Theobroma cacao</i>	147				
			Malvaceae	<i>Gossypium raimondii</i>	246			
				<i>Gossypium arboreum</i>	225			
	Myrtales	Myrtaceae	<i>Eucalyptus camaldulensis</i>	140				
			Brassicales	Brassicaceae	<i>Arabidopsis thaliana</i>	1136		
	<i>Arabidopsis lyrata</i>	1567						
	<i>Raphanus sativus</i>	653						
		<i>Brassica rapa</i>	433					
		<i>Brassica oleracea</i>	132					
		Ericales	Ericaceae	<i>Vaccinium macrocarpon</i>	207			
	Solanales			Solanaceae	<i>Solanum tuberosum</i>	486		
			<i>Nicotiana glauca</i>		385			
		<i>Capsicum annuum</i>	359					
		<i>Daucus carota</i>	186					
		Aquifoliales	Aquifoliaceae	<i>Ilex paraguariensis</i>	158			
	Caryophyllales			Amaranthaceae	<i>Beta vulgaris</i>	137		
		Proteales	Nelumbonaceae		<i>Nelumbo nucifera</i>	179		
	Amborellales			Amborellaceae	<i>Amborella trichopoda</i>	412		
		Pinopsida	Pinaceae		<i>Picea abies</i>	244		
	Chlorophyceae			Chlamydomonadales	Chlamydomonadaceae	<i>Chlamydomonas reinhardtii</i>	171	
		Rhodophyta	Florideophyceae			Gigartinales	Gigartinaceae	<i>Chondrus crispus</i>
	Haptista	Coccolithophyceae	Isochrysidales	Isochrysidaceae	<i>Tisochrysis lutea</i>	207		
Ciliophora	Spirotrichea		Oxytrichidae	<i>Oxytricha trifallax</i>	194			
Oomycota		Peronosporales	Peronosporaceae	<i>Phytophthora infestans</i>	465			
				<i>Phytophthora sojae</i>	166			
				<i>Phytophthora ramorum</i>	119			

Table 7. Repbase entries from the genus *Puccinia* and its relatives.

Species	Abbr.	Rebase entries	2024 Increase
<i>P. triticina</i> (wheat leaf rust, or brown rust)	PTrit	506	219
<i>P. graminis</i> (stem rust, or black rust)	PG/PGra	340	43
<i>P. striiformis</i> (stripe rust, or yellow rust)	PSt	303	14
<i>P. hordei</i> (barley brown rust)	PHord	303	17
<i>P. coronata</i> (barley crown rust)	PCor	296	121
<i>P. horiana</i> (chrysanthemum white rust)	PHor	48	23
<i>Austropuccinia psidii</i> (myrtle rust)	AuPs	232	232
<i>Melampsora larici-populina</i>	MLP	507	7
<i>Melampsora americana</i>	MelAme	52	52
<i>Hemileia vastatrix</i> (coffee leaf rust)	HemVas	172	172
<i>Phakopsora pachyrhizi</i> (Asian soybean rust)	PhaPac	195	195

¹ Only species with >10 entries are shown.

Table 8. TE classification and the numbers of entries in Repbase.

A. LTR retrotransposon

Superfamily	Total	2024 increase	2023 increase	2022 increase
<i>Gypsy</i>	29538	3457	3972	4508
<i>Copia</i>	11197	1214	514	605
<i>BEL</i>	6398	1795	581	974
<i>DIRS</i>	1576	439	201	104
Endogenous Retrovirus (ERV)				
<i>ERV1</i>	4550	116	549	1578
<i>ERV2</i>	2725	-20	305	877
<i>ERV3</i>	1349	11	146	375
<i>ERV4</i>	202	0	0	9
<i>Lentivirus</i>	6	0	0	0
<i>Lokiretrovirus</i>	73	12	6	4
<i>Spumaretrovirus</i>	8	0	1	1
Unclassified ERV	244	-17	-69	4
Unclassified LTR retrotransposon	1094	342	-22	38
Total	58960	7357	6188	9077

B. Penelope-like retrotransposon

Superfamily	Total	2024 increase	2023 increase	2022 increase
<i>Penelope/Poseidon</i>	348	4	3	52
<i>Neptune</i>	665	429	11	5
<i>Nematis</i>	5	0	0	0
<i>Athena</i>	42	0	0	0
<i>Coprina</i>	15	0	0	3
<i>Hydra</i>	28	0	0	6
<i>Naiad/Chlamys</i>	119	0	0	110
Unclassified <i>Penelope</i>	23	0	1	5
Total	1245	433	15	181

C. Non-LTR retrotransposon

Superfamily (clade)	Total	2024 increase	2023 increase	2022 increase
SINE				
<i>SINE1/7SL</i>	223	0	31	92
<i>SINE2/tRNA</i>	2398	63	547	977
<i>SINE3/5S</i>	35	2	1	6
<i>SINEU/snRNA</i>	17	0	0	0
Unclassified SINE	74	0	-1	2
<i>CRE</i>	91	4	32	2
<i>R4</i>	58	0	2	3
<i>Hero</i>	33	1	3	1
<i>NeSL</i>	119	0	0	0
<i>R2</i>	186	2	3	21
<i>RandI/Dualen</i>	13	0	0	0
<i>Proto1</i>	10	0	0	0
<i>L1</i>	4641	457	783	1237
<i>Tx1</i>	435	28	36	66
<i>RTETP</i>	1	0	0	0
<i>Proto2</i>	74	6	15	1
<i>RTEX</i>	322	24	4	141
<i>RTE</i>	780	19	86	108
<i>Outcast</i>	41	0	3	7
<i>Ingi</i>	45	9	2	8
<i>Vingi</i>	155	1	1	0
<i>I</i>	251	0	15	28
<i>Nimb</i>	227	44	57	9
<i>Tad1</i>	550	2	29	32
<i>Loa</i>	98	0	8	2
<i>R1</i>	316	4	18	15
<i>Jockey</i>	383	14	26	44
<i>Rex1</i>	142	1	3	5
<i>CR1</i>	1111	62	73	59
<i>Kiri</i>	136	6	22	3
<i>L2</i>	329	11	7	12
<i>L2A</i>	7	0	0	2
<i>L2B</i>	29	0	0	0
<i>Crack</i>	134	0	-14	5
<i>Daphne</i>	392	55	92	6
<i>Ambal</i>	8	0	0	0
Unclassified non-LTR retrotransposon	398	-48	221	23
Total	14262	767	2105	2917

D. DNA transposon

Superfamily	Total	2024 increase	2023 increase	2022 increase
<i>EnSpm/CACTA</i>	1436	158	133	37
<i>Transib</i>	259	1	33	43
<i>hAT</i>	6209	362	572	557
<i>MuDR</i>	2626	325	188	68
<i>P</i>	322	20	29	27
<i>Kolobok</i>	964	112	50	411
<i>Dada</i>	171	0	0	120
<i>Mariner/Tc1</i>	4932	177	731	865
<i>Zator</i>	106	5	7	5
<i>piggyBac</i>	632	26	57	118
<i>Merlin</i>	151	3	35	20
<i>Harbinger</i>	2294	138	224	146
<i>ISL2EU</i>	218	15	11	28
<i>Ginger1</i>	22	0	2	-19
<i>Ginger2/TDD</i>	71	5	2	20
<i>IS3EU</i>	91	13	33	0
<i>IS481EU</i>	30	0	30	-
<i>Sola</i>				
<i>Sola1</i>	180	18	23	30
<i>Sola2</i>	169	10	35	21
<i>Sola3</i>	51	6	1	0
<i>Academ</i>	543	133	23	24
<i>Novosib</i>	9	0	0	0
<i>Zisupton</i>	44	0	1	1
<i>Helitron</i>	2062	130	242	250
<i>Replitron</i>	36	0	36	-
<i>Polinton</i>	252	18	39	41
<i>Crypton</i>				
<i>CryptonF</i>	26	0	2	0
<i>CryptonA</i>	31	0	13	0
<i>CryptonI</i>	30	0	20	0
<i>CryptonS</i>	59	0	0	0
<i>CryptonV</i>	59	0	6	0
Unclassified <i>Crypton</i>	91	0	2	0
Unclassified DNA transposon	2323	-33	23	22
Total	26497	1640	2603	2816

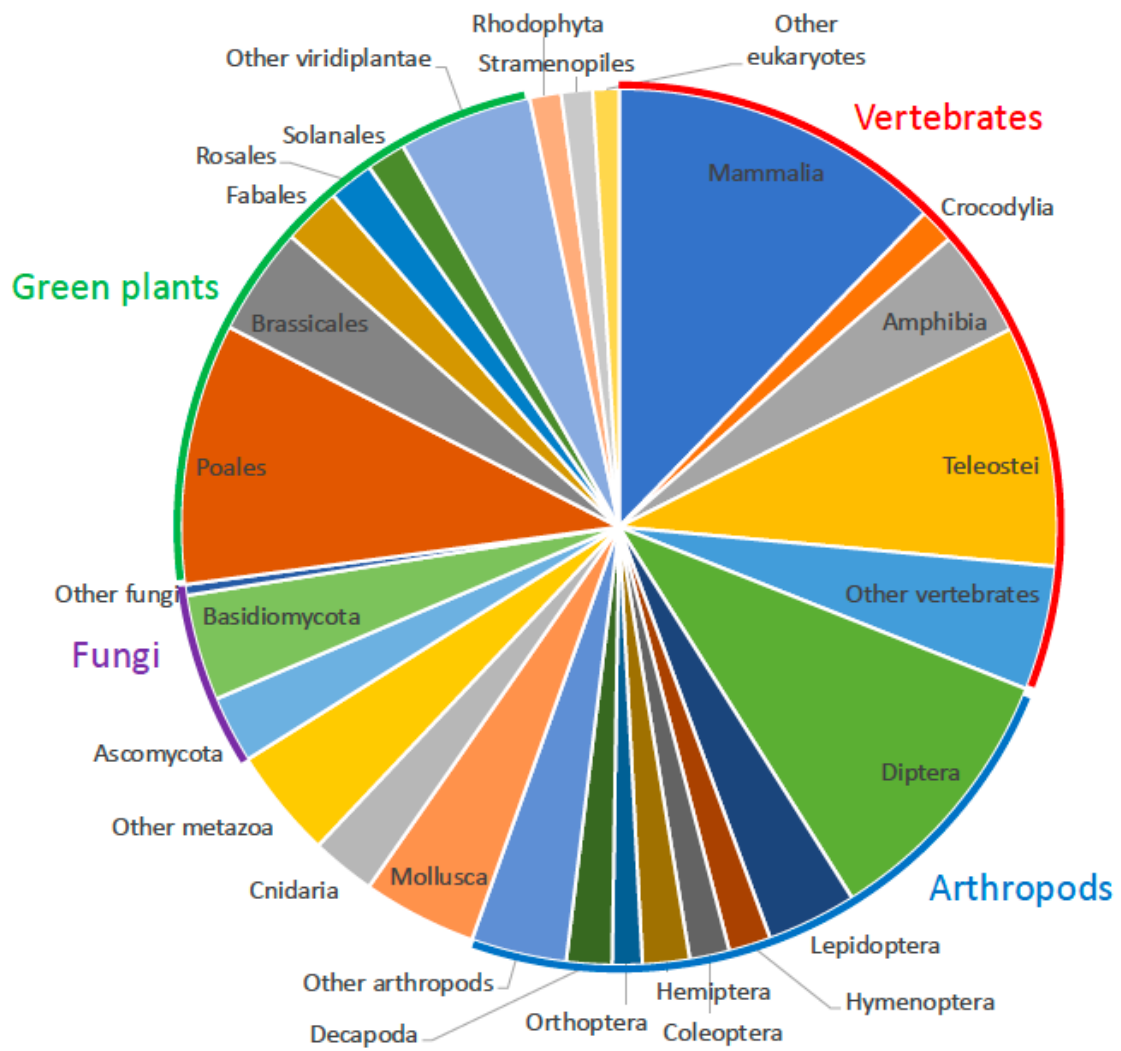


Figure 1. Proportions of Rebase entries in phylogenetic lineages. Lineages with over 1000 entries are shown.

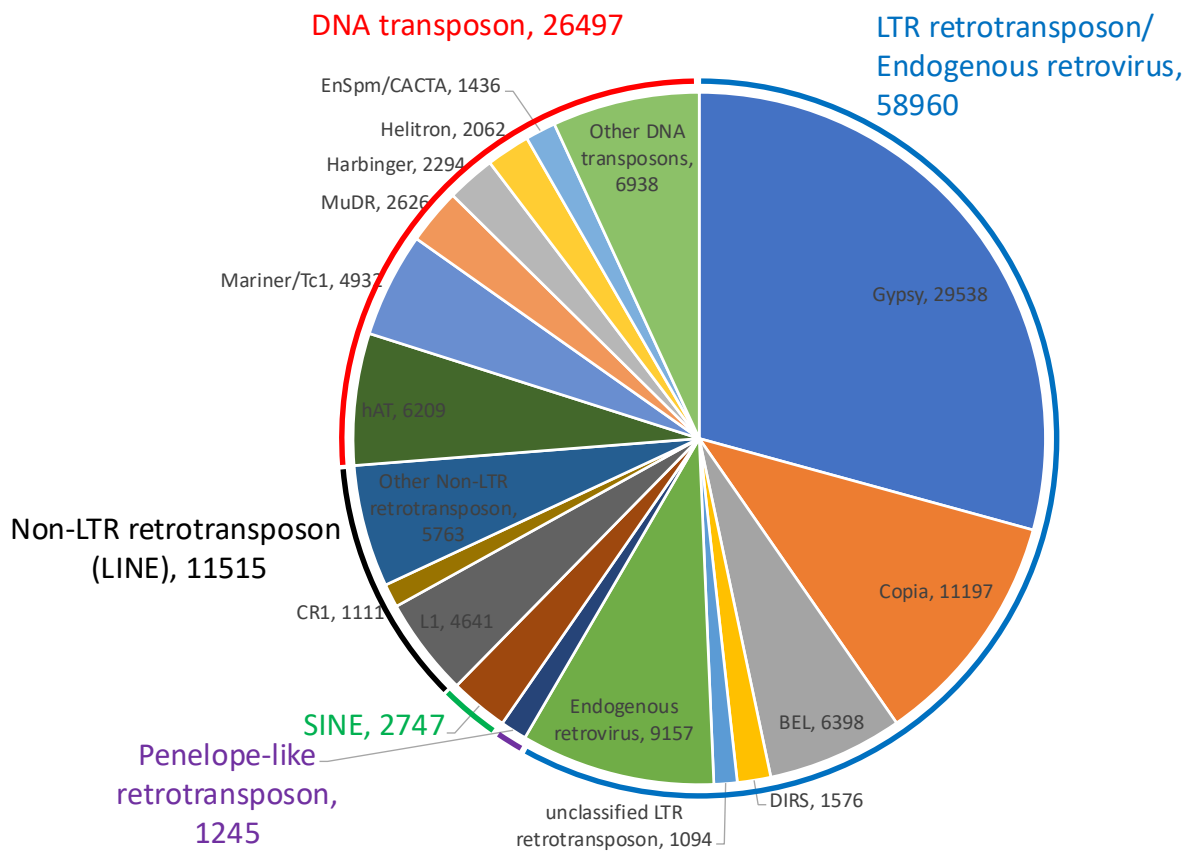


Figure 2. Proportions of Rebase entries in transposon groupings. Groups with over 1000 entries are shown. Numbers after the group names show the numbers of Rebase entries.