

Genome project tables in the genomes package

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The number of genome sequencing projects submitted to public sequence databases is growing rapidly. In addition to the raw sequence data, the amount of associated metadata describing each project is also increasing. The **genomes** package collects genome project metadata from NCBI (<http://www.ncbi.nlm.nih.gov>) and provides tools to summarize, compare and plot the data in the R programming environment.

Genome tables are a defined class (*genomes*) and each table is a data frame where rows are genome projects and columns are the fields describing the associated metadata. At a minimum, the table should have a column listing the project name, status, and release date. A number of methods are available that operate on genome tables including **print**, **summary**, **plot** and **update**.

There are a number of ways to install this package. If you are running the most recent R version, you can use the **biocLite** command.

```
R> source("http://bioconductor.org/biocLite.R")
R> biocLite("genomes")
```

Since the format of online genome tables may change (and then **update** commands may fail), I would recommend downloading the development version for fixes in between the six month release cycle.

```
R> install.packages("genomes",
  repos="http://www.bioconductor.org/packages/devel/bioc")
```

Genome tables from the Genome Project database at NCBI include prokaryotic projects (**lproks**), eukaryotic projects (**leuks**), metagenomes (**lenvs**) and viruses (**virus**). The **print** methods displays the first few rows and columns of the table (either select less than seven rows or convert the object to a **data.frame** to print all columns). The **summary** function displays the download date, a count of projects by status, and a list of recent submissions. The **plot** method displays a cumulative plot of genomes by release date (Figure 1, use **lines** to add additional tables).

```
R> data(lproks)
R> lproks
```

A genomes data.frame with 5439 rows and 32 columns

	pid		name	status
1	33011		Abiotrophia defectiva ATCC 49176	Assembly
2	12997		Acaryochloris marina MBIC11017	Complete
3	16707		Acaryochloris sp. CCMEE 5410	In Progress
4	45843		Acetivibrio cellulolyticus CD2	Assembly
5	52649		Acetobacter aceti NBRC 14818	Assembly
...
5439	34927	Zymomonas mobilis subsp. pomaceae	ATCC 29192	In Progress
	released	...		
1	2009-03-17	...		
2	2007-10-16	...		
3	<NA>	...		
4	2010-08-11	...		
5	<NA>	...		
...		
5439	<NA>	...		

```
R> summary(lproks)
```

```
$`Total genomes`
```

```
[1] 5439 genome projects on Mar 15, 2011
```

```
$`By status`
```

	Total
In Progress	2133
Assembly	1821
Complete	1485

```
$`Recent submissions`
```

	RELEASED	NAME	STATUS
1	2011-03-10	Yersinia enterocolitica subsp. palearctica 105.5R(r)	Complete
2	2011-03-09	Xanthomonas gardneri ATCC 19865	Assembly
3	2011-03-09	Xanthomonas perforans 91-118	Assembly
4	2011-03-09	Xanthomonas vesicatoria ATCC 35937	Assembly
5	2011-03-08	Chlamydophila psittaci 6BC	Complete

```
R> plot(lproks, log = "y", las = 1)
```

```
R> data(leuks)
```

```
R> data(lenvs)
```

```
R> lines(leuks, col = "red")
```

```
R> lines(lenvs, col = "green3")
```

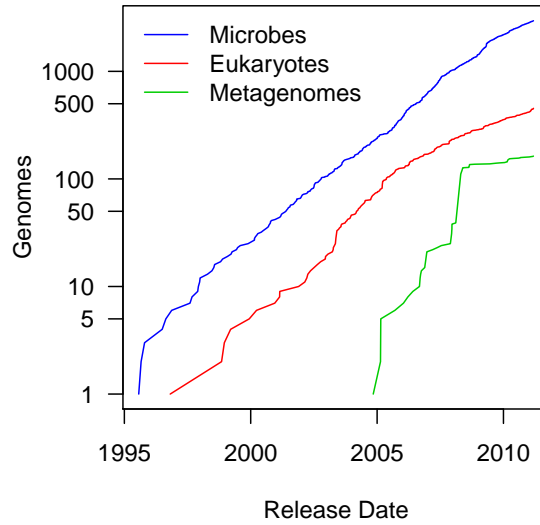


Figure 1: Cumulative plot of genome projects by release date at NCBI.

```
R> legend("topleft", c("Microbes", "Eukaryotes", "Metagenomes"),
      lty = 1, bty = "n", col = c("blue", "red", "green3"))
```

Most importantly, the `update` method downloads the latest version of the table from NCBI and displays a message listing the number of project IDs added and removed (not run).

```
R> update(lproks)
```

A number of additional functions assist in selecting, sorting and grouping genomes. The `species` and `genus` functions can be used to extract the species or genus from a scientific name. The `table2` function formats and sorts a contingency table by counts.

```
R> spp <- species(lproks$name)
R> table2(spp)
```

	Total
Escherichia coli	338
Staphylococcus aureus	206
Salmonella enterica	140
Streptococcus pneumoniae	92
Mycobacterium tuberculosis	83
Enterococcus faecalis	73
Propionibacterium acnes	72
Acinetobacter baumannii	67
Staphylococcus epidermidis	67
Streptococcus mutans	60

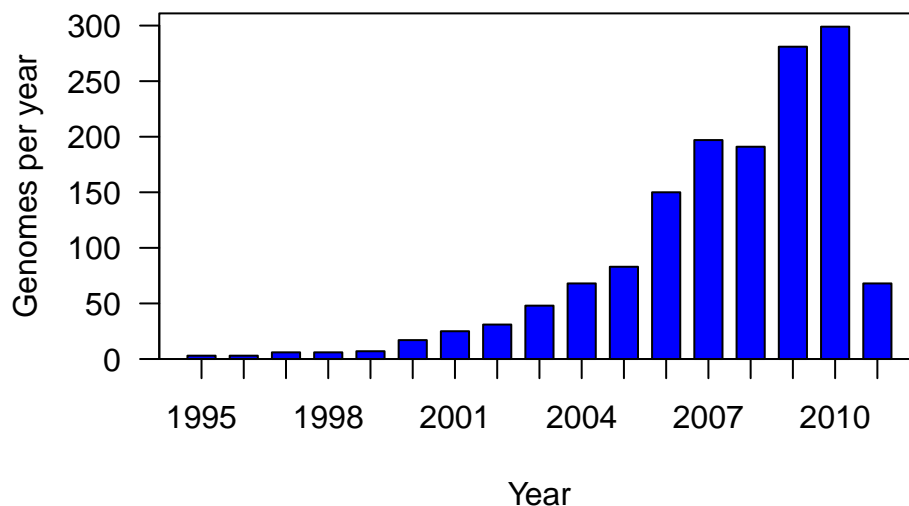


Figure 2: Number of complete microbial genomes released each year at NCBI

The `month` and `year` functions can be used to extract the month or year from the release date (Figure 2).

```
R> complete <- subset(lproks, status == "Complete")
R> x <- table(year(complete$released))
R> barplot(x, col = "blue", ylim = c(0, max(x) * 1.04), space = 0.5,
  las = 1, axis.lty = 1, xlab = "Year", ylab = "Genomes per year")
R> box()
```

Because subsets of tables are often needed, the binary operator `like` allows pattern matching using wildcards. The `plotby` function can then be used to plot the release dates by status using labeled points, in this case to identify complete and draft sequences of *Yersinia pestis* (Figure 3).

```
R> yp <- subset(lproks, name %like% "Yersinia pestis*")
R> plotby(yp, labels = TRUE, cex = 0.5, lty = "n")
```

A number of recent functions have been added that allow R users to run Entrez queries. For example, users can retrieve genome summaries or neighbors using a valid Entrez search query, list taxonomy names matching taxonomy ids, find the published dates of pubmed ids, or return the release dates given accession numbers. The full details about these functions and many others can be found in `genomes` help pages.

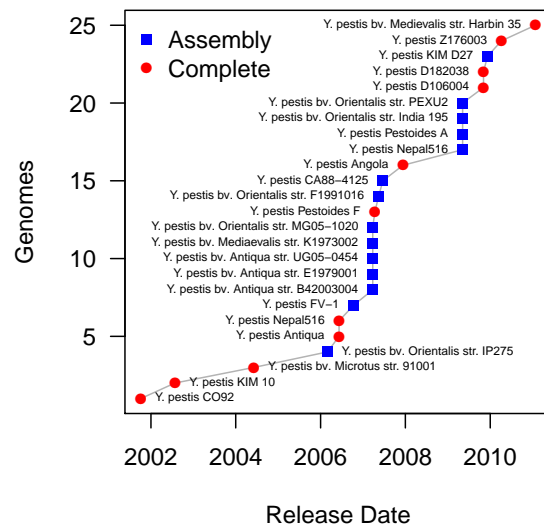


Figure 3: Cumulative plot of *Yersinia pestis* genomes by release date.