Introduction à R... en 1h45

Ecole de Bioinformatique AVIESAN-IFB, Roscoff 2017

Hugo Varet (Institut Pasteur) 2017-11-14

Contents

	Quelques liens utiles
	R vu comme une calculatrice
	Terminez votre commande!
	Pendant le calcul, pas d'invite de commande
	Utiliser des variables
	Nommer ses variables avec des noms informatifs
	Ne pas exagérer dans la longueur des noms de variables sinon cela nuit à la lisibilité du code, comme
	quand on fait des titres à rallonge qui n'aident pas non plus
	Noms réservés
Γ_{i}	ypes de données
	Données numériques
	Chaînes de charactères
	Variables Booléennes (logiques, binaires)
31	cructures de données
	Vecteurs
	Caractéristiques d'un vecteur
	Sélection/suppression d'éléments d'un vecteur
	Opérations sur des vecteurs
	Création de séquences de nombres
	Valeurs non définies (NA)
	Facteurs
	Définir un ordre sur les niveaux d'un facteur
	Traitement des valeurs non-assignées (NA)
	Matrices
	Caractéristiques d'une matrice
	Opérations sur des matrices
	Elément par élément
	Produit matriciel (attention aux dimensions)
	Somme, moyenne,
	Sélection/suppression d'éléments d'une matrice
	Structures de données de type liste
	Liste contenant une liste
	Extraction d'éléments d'une liste
	Strctures de données de type data.frame
	Caractéristiques d'une data.frame
	Sélection de colonnes
	Sélection de lignes
	Résumé statistique
	Fusion de deux data frames
	Création d'une nouvelle variable

A l'aide	17
Aide dans R	17
Aide sur le web	17
Aide ici	17
Espace de travail	18
Où suis-je ?	18
Où vais-je?	18
Lire et écrire des données	18
Quuelques manipulations de fichiers	18
Charger les données à partir d'un fichier texte	19
Charger les données à partir d'un fichier type CSV	20
Ecriture d'une table de données dans un fichier texte	
Environnement R	21
Liste des objets présents dans l'environnement R	21
Suppression d'objets de la mémoire	
Sauvegarde de tout l'environnement	
Suppression de tous les éléments présents dans la session R	
Sauvegarde d'un objet spécifique	
Chargement d'un objet/environnement	
Graphiques	23
Nuage de points (XY plot)	
Boîte à moustaches (boxplot)	
Histogramme	
Diagramme en bâtons (barplot)	
Personnalisation des graphiques	
Couleurs disponibles	
Notions basiques de programmation	31
Fonctions	
Condition	
Attention: une seule chose doit être testée	
Boucles	
While (tant que)	33
Packages	34
Chargement d'un package déjà installé	34
Installation d'un package disponible sur le CRAN	34
installation d'un package disponible sur BioConductor	34
Modélisation statistique	34
Modèle linéaire simple	34
Interprétation graphique	35
Et plein d'autres choses	36

Quelques liens utiles

- Projet R: http://www.r-project.org
- Télécharger \hat{R} + des bibliothèques de fonctions: http://cran.r-project.org
- L'environnement de travail RStudio: https://www.rstudio.com

- Bioconductor, des bibliothèques de fonction pour la biologie: http://www.bioconductor.org
- R cheat sheet (antisèche): https://www.rstudio.com/wp-content/uploads/2016/10/r-cheat-sheet-3.pdf
- R basics and easy: http://www.sthda.com/english/wiki/r-basics-quick-and-easy
- Google R style guide: https://google.github.io/styleguide/Rguide.xml#identifiers

R vu comme une calculatrice

Le symbole ">" est l'invite de commande ("prompt") de \mathbf{R} . Ilsignifie que \mathbf{R} est prêt à recevoir une nouvelle instruction. Exemple:

```
## Quelques calculs
2 + 3

## [1] 5
2 * 3

## [1] 6
2 / 3
```

[1] 0.6666667

Terminez votre commande!

Quand vous entrez une commande incomplète, R affiche une invite +, qui indique qu'il attend que vous complétiez votre commande

2 *

Si vous êtes coincés avec une invite +, vous devez terminer la commande pour vous tirer d'affaire. Dans ce cas-ci, tapez par exemple taper 7 puis ENTER.

Pendant le calcul, pas d'invite de commande

Si on envoie à R un calcul qui dure un certain temps, pendant le calcul il n'affiche aucun symbole d'invite de commande.

Un exemple de commande qui prend quelques secondes (nous expliquerons plus bas en quoi consistent ces fonctions).

Note: le symbole # permet d'écrire des commentaires, i.e. du texte non interprété par R.

```
## Calculer la moyenne de 100 millions de nombres
## tirés au hasard selon une distribution normale
mean(rnorm(100000000))
```

[1] -1.539544e-05

Pendant quelques secondes rien ne se passe ... puis la réponse s'affiche.

Utiliser des variables

Le symbole <- assigne une valeur à une variable. Si cette variable n'a pas encore déclarée, elle est créée au passage (un espace mémoire lui est réservé).

```
a <- 2 ## Assignation d'une valeur à une variable
b = 3 ## Notation équivalente acceptée mais pas recommandée
```

Nommer ses variables avec des noms informatifs

Plutôt que a,b,c , on recommande de nommer les varables de façon explicite

```
resultat <- a * b + a + b \#\# Le résultat est stocké dans une variable nommée resultat print(resultat)
```

```
## [1] 11
```

Attention! Les noms de variables sont sensibles à la casse! La commande suivante retourne une erreur.

```
print(Resultat)
```

Error in print(Resultat): object 'Resultat' not found

Ne pas exagérer dans la longueur des noms de variables sinon cela nuit à la lisibilité du code, comme quand on fait des titres à rallonge qui n'aident pas non plus

```
ma_nouvelle_variable_avec_un_nom_a_rallonge <- 10
```

Noms réservés

Attention: certains noms sont déjà utilisés pour des fonctions/objets \mathbf{R} . Il ne faut donc pas les utiliser comme noms de variables. On les qualifie de **noms réservés**.

```
c # créer un vecteur
t # transposer une matrice
sum # fonction somme
mean # fonction moyenne

TRUE # booléen
FALSE # booléen
T # booléen
F # booléen
NA # not available
NaN # not a number (par exemple log(-1))
Inf # infini (par exemple 1/0)
NULL # objet nul

pi # 3.14...
letters # 26 lettres minuscules
LETTERS # 26 lettres majuscules
```

Types de données

Données numériques

Par défaut les nombres sont considérés comme des variables numériques de type "floating point" (variables réelles), même si leur valeur particulière est entière.

```
# "double precision floating point numbers"
x <- 3
print(x)

## [1] 3

mode(x)

## [1] "numeric"

typeof(x)

## [1] "double"

On peut cependant explicitement déclarer une variable entière avec as.integer()
y <- as.integer(2)
print(y)

## [1] 2

mode(y)

## [1] "numeric"

typeof(y)

## [1] "integer"</pre>
```

Chaînes de charactères

Les variables de type "character" permettent de stocker des chaînes de caractères.

```
x <- "chaîne de caractères, toujours entre guillemets"
print(x)</pre>
```

Intérêt: les variables de type "Integer" utilisent moins d'espace mémoire que les "Floating point".

[1] "chaîne de caractères, toujours entre guillemets"

```
y <- 'ou avec des guillemets simples'
print(y)</pre>
```

[1] "ou avec des guillemets simples"

```
mode(x) ## type de contenu de la variable x
```

[1] "character"

```
nchar(x) ## lontgueur d'une chaîne de caractères
```

[1] 47

paste(x, y, sep=" / ") ## concaténation de variables de type character

[1] "chaîne de caractères, toujours entre guillemets / ou avec des guillemets simples"

Variables Booléennes (logiques, binaires)

```
x <- TRUE # ou T ou FALSE ou F
print(x)

## [1] TRUE

mode(x)

## [1] "logical"

# sera utile pour tester des choses :
    # if (condition) {
    # faire ça
    # } else {
    # faire autre chose</pre>
```

Structures de données

Vecteurs

Un vecteur permet de stocker dans une seule variable une liste d'élements du même type (numeric, character...).

Un vecteur peut contenir des valeurs de différents types: entiers, réells, Booléens, char, ...

```
u <- c(2, 4, 5, 1)
print(u)

## [1] 2 4 5 1

v <- c(10, 5, 2, 2)
print(v)

## [1] 10 5 2 2

w <- c("Pierre", "Paul", "Jacques", "Henri")
print(w)

## [1] "Pierre" "Paul" "Jacques" "Henri"

1 <- c(TRUE, FALSE, FALSE, TRUE)
print(1)</pre>
```

[1] TRUE FALSE FALSE TRUE

Caractéristiques d'un vecteur

```
length(u)
```

[1] 4

```
mode(u)
## [1] "numeric"
mode(w)
## [1] "character"
mode(1)
## [1] "logical"
Sélection/suppression d'éléments d'un vecteur
u[2]
## [1] 4
u[-2]
## [1] 2 5 1
u[c(1, 3)]
## [1] 2 5
u[1]
## [1] 2 1
u >= 3
## [1] FALSE TRUE TRUE FALSE
u[which(u >= 3)]
## [1] 4 5
v %in% c(2, 5)
## [1] FALSE TRUE TRUE TRUE
v[which(v %in% c(2, 5))]
## [1] 5 2 2
Opérations sur des vecteurs
sort(u)
## [1] 1 2 4 5
summary(u)
```

Min. 1st Qu. Median Mean 3rd Qu.

Min. 1st Qu. Median Mean 3rd Qu. Max. ## 1.00 1.75 3.00 3.00 4.25 5.00

sum(u)

[1] 12

```
mean(u)
## [1] 3
u + v
## [1] 12 9 7 3
u * v
## [1] 20 20 10 2
u / v
## [1] 0.2 0.8 2.5 0.5
cbind(u, v)
      u v
## [1,] 2 10
## [2,] 4 5
## [3,] 5 2
## [4,] 1 2
rbind(u, v)
   [,1] [,2] [,3] [,4]
## u 2
         4 5 1
## v
                2
                     2
    10
           5
Création de séquences de nombres
1:10
## [1] 1 2 3 4 5 6 7 8 9 10
seq(from=1, to=100, by=10)
## [1] 1 11 21 31 41 51 61 71 81 91
seq(from=1, to=100, length=4)
## [1] 1 34 67 100
rep(x=c(1, 2), times=3)
## [1] 1 2 1 2 1 2
rep(x=c(1, 2), each=3)
## [1] 1 1 1 2 2 2
Valeurs non définies (NA)
u \leftarrow c(4, NA, 5, 2, NA, 3)
mean(u)
```

[1] NA

```
mean(u, na.rm=TRUE)
```

[1] 3.5

Facteurs

Les structures de données de type factor permettent de traiter des listes d'éléments dont les valeurs appartiennent à un ensemble défini. Ces valeurs sont indexées pour assurer une efficacité maximale du traitement informatique.

```
## Un vecteur
mentions <- c("Passable", "AB", "AB", "B", "TB", "TB", "Passable", "B", "Passable", "TB")
print(mentions)
    [1] "Passable" "AB"
                                "AB"
                                           "B"
                                                       "TB"
                                                                   "TB"
    [7] "Passable" "B"
                                "Passable" "TB"
f <- factor(mentions)</pre>
print(f) # Afficher le contenu du facteur
    [1] Passable AB
##
                            AB
                                     В
                                              TB
                                                        TB
                                                                  Passable
   [8] B
                  Passable TB
## Levels: AB B Passable TB
levels(f)
## [1] "AB"
                   "B"
                               "Passable" "TB"
table(f)
## f
##
                                      TB
         AB
                    B Passable
##
           2
                    2
                              3
                                       3
```

Définir un ordre sur les niveaux d'un facteur

```
# notion d'ordre
f <- factor(mentions, levels=c("Passable", "AB", "B", "TB"))</pre>
print(f) # Afficher le contenu du facteur
   [1] Passable AB
                                     В
                                              TΒ
                                                        TΒ
                           AB
                                                                 Passable
   [8] B
                  Passable TB
## Levels: Passable AB B TB
levels(f)
## [1] "Passable" "AB"
                               "B"
                                          "TB"
table(f)
## f
## Passable
                                      TΒ
                   AΒ
                             В
                             2
                                       3
##
          3
                    2
```

Traitement des valeurs non-assignées (NA)

```
f <- factor(c("Passable", NA, "AB", "AB", NA, "B"), levels=c("Passable", "AB", "B", "TB"))
print(f)
## [1] Passable <NA>
                                AB
                                        <NA>
                                                 В
## Levels: Passable AB B TB
levels(f)
## [1] "Passable" "AB"
                           "B"
                                      "TB"
table(f) # Où sont passées les valeurs NA ?
## f
## Passable
                          В
                                  TΒ
                 AB
##
                  2
                          1
                                   0
## Imprimer les valeurs NA seulement si elles existent
table(f, useNA="ifany")
## f
## Passable
                          В
                 AB
                                  TB
                                        <NA>
##
                  2
                          1
                                  0
         1
                                           2
Matrices
m <- matrix(rnorm(30), nrow=6, ncol=5)</pre>
print(m)
             [,1]
                        [,2]
                                    [,3]
                                              [,4]
                                                        [,5]
## [1,] -0.1486693 -0.28296737 -0.76238248 0.9479041 -1.6204523
## [2,] 0.6535759 -0.44515827 0.84048931 -0.1871061 -0.7545087
## [3,] -0.3797459 -0.11648153 1.55622311 -0.1995298 0.2557268
## [4,] 1.7064558 0.22027793 0.04678722 -0.5187219 1.6761666
## [5,] 0.1336223 -0.01676033 0.07574837 0.9711863 2.4848836
```

```
n <- matrix(c("a","b","c","d","e","f"), ncol=3, byrow=TRUE)</pre>
print(n)
```

```
[,1] [,2] [,3]
## [1,] "a"
            "b"
                  "c"
## [2,] "d"
            "e"
                  "f"
```

Caractéristiques d'une matrice

```
# caractéristiques d'une matrice
ncol(m)
```

[1] 5

```
nrow(m)
## [1] 6
dim(m)
## [1] 6 5
length(m)
## [1] 30
mode(m)
## [1] "numeric"
mode(n)
## [1] "character"
Opérations sur des matrices
mat1 <- matrix(1:6, nrow=2, ncol=3)</pre>
mat2 <- matrix(rnorm(6), nrow=2, ncol=3)</pre>
print(mat1)
##
        [,1] [,2] [,3]
## [1,]
           1
                3
## [2,]
                     6
print(mat2)
             [,1]
                        [,2]
## [1,] 1.6494294 0.5193190 0.3361214
## [2,] 0.6289246 -0.2775338 -0.4121806
Elément par élément
mat1 + mat2
##
                      [,2]
                               [,3]
            [,1]
## [1,] 2.649429 3.519319 5.336121
## [2,] 2.628925 3.722466 5.587819
mat1 * mat2
                                 [,3]
##
                      [,2]
            [,1]
## [1,] 1.649429 1.557957 1.680607
## [2,] 1.257849 -1.110135 -2.473083
Produit matriciel (attention aux dimensions)
```

mat1 %*% t(mat2)

```
##
            [,1]
                      [,2]
## [1,] 4.887994 -2.264579
## [2,] 7.392864 -2.325369
t(mat1) %*% mat2
             [,1]
                         [,2]
## [1,] 2.907279 -0.03574849 -0.4882397
## [2,] 7.463987 0.44782205 -0.6403580
## [3,] 12.020695 0.93139258 -0.7924762
Somme, moyenne, ...
sum(mat1) # de tous les éléments
## [1] 21
rowSums(mat1) # des éléments de chaque ligne
## [1] 9 12
colSums(mat1) # des éléments de chaque colonne
## [1] 3 7 11
mean(mat1)
## [1] 3.5
rowMeans(mat1)
## [1] 3 4
colMeans(mat1)
## [1] 1.5 3.5 5.5
Sélection/suppression d'éléments d'une matrice
mat1[, c(2, 3)]
        [,1] [,2]
##
## [1,]
## [2,]
                6
mat1[1,]
## [1] 1 3 5
mat1[1, c(2, 3)]
```

[1] 3 5

Structures de données de type liste

```
11 <- list(n = c(TRUE, FALSE),</pre>
print(11)
## $n
## [1] TRUE FALSE
##
## $v
## [1] 3 4
##
## $r
## [1] "toto" "plop" "tutu"
## [[4]]
        [,1] [,2] [,3]
##
## [1,]
           1
                3
## [2,]
           2
                4
                      6
length(11)
## [1] 4
names(11)
## [1] "n" "v" "r" ""
Liste contenant une liste
12 <- list(a="chaîne de caractères", 11=11)
print(12)
```

```
## $a
## [1] "chaîne de caractères"
##
## $11
## $11$n
## [1] TRUE FALSE
##
## $11$v
## [1] 3 4
##
## $11$r
## [1] "toto" "plop" "tutu"
##
## $11[[4]]
       [,1] [,2] [,3]
## [1,]
        1 3
                    5
## [2,]
          2
               4
```

Extraction d'éléments d'une liste

4 Mathieu

170

```
# extraction d'éléments d'une liste
11$n
## [1] TRUE FALSE
12$11
## $n
## [1] TRUE FALSE
##
## $v
## [1] 3 4
##
## $r
## [1] "toto" "plop" "tutu"
##
## [[4]]
##
        [,1] [,2] [,3]
## [1,]
           1
                3
## [2,]
           2
                4
                     6
12$11$v
## [1] 3 4
12[1]
## $a
## [1] "chaîne de caractères"
12[[1]]
## [1] "chaîne de caractères"
is.list(12[1])
## [1] TRUE
is.list(12[[1]])
## [1] FALSE
Strctures de données de type data.frame
# tableau dont les colonnes ne sont pas nécessairement du même type (numeric, character...)
d <- data.frame(nom=c("Pierre", "Paul", "Henri", "Mathieu"),
                taille=c(165, 168, 163, 170),
                poids=c(58, 60, 62, 68))
print(d)
         nom taille poids
## 1 Pierre
                165
                       58
## 2
        Paul
                168
                       60
## 3 Henri
                       62
                163
```

```
class(d)
## [1] "data.frame"
typeof(d) # une data.frame est un cas particulier d'une liste
## [1] "list"
Caractéristiques d'une data.frame
ncol(d)
## [1] 3
nrow(d)
## [1] 4
names(d)
## [1] "nom"
                "taille" "poids"
length(d)
## [1] 3
Sélection de colonnes
# sélection de colonnes
d$taille
## [1] 165 168 163 170
d[, "taille"]
## [1] 165 168 163 170
d[, c("nom", "taille")]
         nom taille
##
## 1 Pierre
## 2
                168
        Paul
## 3
      Henri
                163
## 4 Mathieu
                170
Sélection de lignes
```

##

3

1 Pierre

4 Mathieu

Henri

nom taille poids

165

163

170

58

62

68

```
d$nom == "Pierre"
## [1] TRUE FALSE FALSE FALSE
d[which(d$nom == "Pierre"),]
       nom taille poids
## 1 Pierre
                     58
              165
Résumé statistique
summary(d)
                 taille
                                   poids
        nom
  Henri :1
              Min. :163.0 Min. :58.0
##
   Mathieu:1
##
               1st Qu.:164.5
                              1st Qu.:59.5
               Median :166.5
   Paul :1
                             Median:61.0
  Pierre :1
               Mean :166.5
##
                               Mean
                                     :62.0
##
               3rd Qu.:168.5
                               3rd Qu.:63.5
               Max. :170.0
##
                             Max. :68.0
Fusion de deux data frames
# fusion de deux data frames
d2 <- data.frame(nom=c("Paul","Henri","Louis"), age=c(34, 29, 47))
print(d2)
##
      nom age
## 1 Paul 34
## 2 Henri 29
## 3 Louis 47
merge(x=d, y=d2, by="nom")
       nom taille poids age
## 1 Henri
             163
                    62 29
## 2 Paul
             168
                    60
                        34
merge(x=d, y=d2, by="nom", all=TRUE)
##
        nom taille poids age
## 1
       Henri
               163
                      62
                         29
## 2 Mathieu
               170
                      68 NA
## 3
       Paul
               168
                      60
                          34
## 4 Pierre
               165
                      58
                          NA
## 5
      Louis
                NA
                      NA
                          47
merge(x=d, y=d2, by="nom", all.x=TRUE)
        nom taille poids age
                      62 29
## 1
               163
      Henri
## 2 Mathieu
               170
                      68 NA
```

3

Paul

4 Pierre

168

165

60 34

58 NA

merge(x=d, y=d2, by="nom", all.y=TRUE) ## nom taille poids age ## 1 Henri 163 62 29 ## 2 Paul 168 60 34 ## 3 Louis NA NA 47

Création d'une nouvelle variable

```
print(d)
##
         nom taille poids
## 1
      Pierre
                 165
## 2
        Paul
                 168
                        60
## 3
       Henri
                 163
                        62
## 4 Mathieu
                 170
                        68
d$age <- c(35, 42, 31, 28)
d$classe_poids <- ifelse(test=d$poids >= 60, yes=">=60", no="<60")
print(d)
##
         nom taille poids age classe_poids
## 1 Pierre
                 165
                        58 35
                                        <60
## 2
        Paul
                 168
                        60
                            42
                                        >=60
## 3
       Henri
                                        >=60
                 163
                        62
                            31
## 4 Mathieu
                 170
                        68 28
                                       >=60
```

A l'aide

Aide dans R

```
help(read.table)
?read.table
```

Aide sur le web

- Google!!!
- plein de forums dédiés: par exemple https://stackoverflow.com/
- mailing list: https://www.r-project.org/mail.html
- spéficique Bioconductor: https://support.bioconductor.org/

Aide ici

• les formateurs!

Espace de travail

Où suis-je?

La commande $\mathbf R$ getwd() est équivalente de la commande Unix pwd vue hier.

```
# où suis-je ? équivalent de la commande Unix 'pwd' getwd()
```

[1] "/Users/jvanheld/Google Drive/EBAI_Roscoff/EBAI_2017-11/Cours/04_R/intro_R"

R	Unix
getwd()	pwd

Où vais-je?

La commande $\mathbf R$ setwd() est équivalente de la commande Unix $\mathbf c \mathbf d$ vue hier.

```
# changement de répertoire courant: équivalent de la commande unix 'cd <path>'
# Chemin relativ
setwd("chemin/acces/au/nouveau/repertoire/")
# Chemin absolu
setwd("/home/hugo/chemin/acces/au/nouveau/repertoire/")
```

R	Unix
setwd()	cd

Lire et écrire des données

Quuelques manipulations de fichiers

R	Unix
list.files()	ls
file.copy()	ср

```
# quelques manipulations de fichiers
f <- list.files(path="/projet/sbr/ggb/intro_R/", full.names=TRUE)
print(f)</pre>
```

character(0)

```
file.copy(from=f, to=getwd())
```

logical(0)

Vérifier ensuite que les fichiers ed données ont bien été copiés dans l'espace de travail.

list.files(path=getwd())

```
## [1] "mon_environnement.RData"
## [2] "objet_a.RData"
## [3] "rnaseq_data.csv"
## [4] "rnaseq_data.txt"
## [5] "rnaseq_export.txt"
## [6] "Saccharomyces_cerevisiae.R64-1-1.90.gtf"
```

list.files() ## Commande équivalente, plus légère

```
## [1] "mon_environnement.RData"
## [2] "objet_a.RData"
## [3] "rnaseq_data.csv"
## [4] "rnaseq_data.txt"
## [5] "rnaseq_export.txt"
## [6] "Saccharomyces_cerevisiae.R64-1-1.90.gtf"
```

Charger les données à partir d'un fichier texte

La commande read.table() permet de charger le contenu d'un fichier dans une variable.

Le fichier rna_seq.txt contient des valeurs séparées par des tabulations (symbole \t).

```
rna <- read.table("rnaseq_data.txt", sep="\t", header=TRUE)</pre>
print(rna)
```

##		geneid	name	WT1	WT2	WT3	KO1	K02	КОЗ
##	1	ENSG00000000003	TSPAN6	64	55	37	62	45	50
##	2	ENSG0000000005	TNMD	0	0	0	0	0	0
##	3	ENSG00000000419	DPM1	8370	5420	6154	7823	5283	5849
##	4	ENSG00000000457	SCYL3	970	811	567	950	669	545
##	5	ENSG00000000460	${\tt C1orf112}$	1689	1113	981	2065	1082	1264
##	6	ENSG00000000938	FGR	44	25	10	24	5	1
##	7	ENSG00000000971	CFH	205	27	32	20	5	7
##	8	ENSG0000001036	FUCA2	1735	688	661	1543	491	414
##	9	ENSG0000001084	GCLC	3526	5007	3802	4207	4583	3514
##	10	ENSG0000001167	NFYA	4730	5398	3725	4556	5408	4173
##	11	ENSG0000001460	STPG1	360	368	265	422	348	302
##	12	ENSG0000001461	NIPAL3	2260	2509	1851	2527	2283	1884
##	13	ENSG0000001497	LAS1L	6007	9238	5271	5469	10413	7290
##	14	ENSG0000001561	ENPP4	1507	795	1240	1427	734	1045
##	15	ENSG0000001617	SEMA3F	1	3	0	5	8	3
##	16	ENSG0000001626	CFTR	0	0	0	0	0	0
##	17	ENSG0000001629	ANKIB1	1855	3210	1515	2182	3073	1567
##	18	ENSG0000001630	CYP51A1	7933	2837	3119	8635	3484	3192
##	19	ENSG0000001631	KRIT1	1200	2225	1115	1491	1872	1183
##	20	ENSG00000002016	RAD52	159	207	76	196	211	93
##	21	ENSG00000002079	MYH16	0	0	0	0	1	0
##	22	ENSG00000002330	BAD	1905	1854	1785	1322	1900	1979
##	23	ENSG00000002549	LAP3	22969	14296	15085	19888	14524	16968
##	24	ENSG00000002586	CD99	16856	27742	22743	14489	21501	18203
##	25	ENSG00000002587	HS3ST1	16	13	6	19	4	1
##	26	ENSG00000002726	AOC1	8	0	0	3	0	0

```
## 27 ENSG00000002745
                            WNT16
                                      58
                                             25
                                                    0
                                                          28
                                                                  9
                                                                        2
                           HECW1
                                       0
                                             0
                                                    0
                                                           0
                                                                  0
                                                                        2
   28 ENSG00000002746
   29 ENSG00000002822
                                                              2396
                           MAD1L1
                                     753
                                          1989
                                                  776
                                                         738
                                                                     1248
   30 ENSG00000002834
                                                11236 11746
                                                             22994
                                                                    13958
##
                           LASP1 10527
                                         21095
      ENSG00000002919
                           SNX11
                                    4362
                                          4239
                                                 3703
                                                        3724
                                                               3887
                                                                     3795
##
                                                    5
                                                           6
                                                                  2
                                                                        3
   32 ENSG00000002933
                        TMEM176A
                                             0
                                       1
                                                 7685 10150
                                                              7153
   33 ENSG00000003056
                            M6PR 11037
                                          7346
                                                                     8069
##
   34
      ENSG00000003096
                          KLHL13
                                      66
                                             53
                                                   26
                                                          97
                                                                134
                                                                       87
   35
      ENSG00000003137
                         CYP26B1
                                       4
                                             0
                                                    4
                                                           1
                                                                  0
                                                                        2
                                             24
                                                                 33
   36
      ENSG00000003147
                             ICA1
                                     156
                                                   26
                                                         145
                                                                       56
   37
      ENSG00000003249
                           DBNDD1
                                      27
                                             32
                                                   17
                                                           8
                                                                 49
                                                                       11
                             ALS2
                                                        1427
                                                               1567
                                                                     1328
##
   38
      ENSG00000003393
                                    1617
                                          1664
                                                 1210
##
   39
      ENSG00000003400
                           CASP10
                                     904
                                           764
                                                  409
                                                        1215
                                                               1004
                                                                      532
                                         56308
                                                41971
                                                             37386
##
   40
      ENSG00000003402
                           CFLAR
                                  39344
                                                      30152
                                                                    27284
                             TFPI
                                       5
                                                    8
                                                          45
   41
      ENSG0000003436
                                             1
                                                                 16
                                                                       12
      ENSG0000003509
                         NDUFAF7
                                     877
                                          1106
                                                  716
                                                         821
                                                               977
                                                                      570
                                   2502
                                          7437
                                                 2398
                                                        2770
                                                               6499
                                                                     2745
##
   43
      ENSG00000003756
                             RBM5
      ENSG00000003987
                           MTMR7
                                       0
                                             0
                                                    2
                                                           0
                                                                  1
                                                                        2
   45 ENSG00000003989
                           SLC7A2
                                             4
                                                    0
                                                           0
                                                                  2
                                                                        0
##
                                       5
      ENSG00000004059
                             ARF5
                                  12018
                                          8963
                                                 9746
                                                       9462
                                                              9168
                                                                     9353
##
   47
      ENSG00000004139
                           SARM1
                                   1154
                                          2913
                                                 1247
                                                        1041
                                                              2420
                                                                     1262
   48 ENSG00000004142
                         POLDIP2
                                  15498
                                         15945
                                                12886
                                                      12785
                                                             18109
                           PLXND1
## 49 ENSG0000004399
                                      32
                                           137
                                                   55
                                                          28
                                                                128
                                                                      102
## 50 ENSG0000004455
                              AK2 19857 17803 16815 17128 18649 17445
```

print(head(rna)) # N'imprimer que le début du fichier

```
##
                                     WT1
                                           WT2
                                                 WT3
                                                       K01
                                                             K<sub>0</sub>2
                                                                   K<sub>0</sub>3
                geneid
                             name
                                                              45
                                                                    50
## 1 ENSG00000000003
                           TSPAN6
                                      64
                                            55
                                                  37
                                                        62
   2 ENSG00000000005
                              TNMD
                                       0
                                             0
                                                   0
                                                         0
                                                               0
                                                                     0
                                                           5283
##
                             DPM1 8370 5420
                                               6154 7823
                                                                 5849
   3 ENSG00000000419
   4 ENSG00000000457
                             SCYL3
                                     970
                                           811
                                                 567
                                                       950
                                                             669
                                                                   545
   5 ENSG00000000460
                         C1orf112 1689
                                         1113
                                                 981
                                                     2065
                                                           1082
                                                                 1264
   6 ENSG00000000938
                               FGR
                                            25
                                                  10
                                                        24
                                                               5
                                      44
```

Charger les données à partir d'un fichier type CSV

Le fichier rna_seq.csv contient des valeurs séparées par des points-virgules (en dépit de son nom "comma-separated values").

- L'option sep permet de spécifier un séparateur de colonnes.
- L'option col.names permet d'assigner des noms aux colonnes pendant la lecture des données.

```
# charger le fichier rnaseq_data.csv
rna2 <- read.table(
   "rnaseq_data.csv", sep=";", header=FALSE,
   col.names=c("geneid","name","WT1","WT2","WT3","K01","K02","K03"))
print(head(rna2))</pre>
```

```
K02
                                                             K03
##
                                  WT1
                                       WT2
                                             WT3
                                                  KO1
               geneid
                           name
   1 ENSG00000000003
                         TSPAN6
                                   64
                                        55
                                              37
                                                   62
                                                         45
                                                               50
   2 ENSG00000000005
                           TNMD
                                    0
                                         0
                                               0
                                                     0
                                                          0
                                                                0
                           DPM1 8370 5420
   3 ENSG00000000419
                                           6154
                                                 7823
                                                       5283 5849
                                                        669
     ENSG00000000457
                                  970
                                       811
                                             567
                                                  950
                                                             545
   4
                          SCYL3
## 5 ENSG0000000460 Clorf112 1689 1113
                                             981 2065 1082 1264
```

```
## 6 ENSG00000000938 FGR 44 25 10 24 5 1
```

Ecriture d'une table de données dans un fichier texte

```
# exporter des données dans un fichier (qui sera écrasé s'il existe déjà !)
write.table(rna, file="rnaseq_export.txt", sep=" ", col.names=FALSE, row.names=FALSE)
```

Environnement R

Liste des objets présents dans l'environnement R

```
ls()
    [1] "a"
    [2] "b"
##
##
    [3] "d"
##
    [4] "d2"
    [5] "dir.tuto"
##
    [6] "f"
##
##
    [7]
        "1"
##
   [8] "11"
   [9] "12"
##
## [10] "m"
## [11] "ma_nouvelle_variable_avec_un_nom_a_rallonge"
## [12] "mat1"
## [13] "mat2"
## [14] "mentions"
## [15] "n"
## [16] "resultat"
## [17] "rna"
        "rna2"
## [18]
## [19] "u"
## [20]
        "v"
        "w"
## [21]
## [22]
        "x"
## [23] "y"
```

Suppression d'objets de la mémoire

```
# Suppression d'un objet (utile si particulièrement lourd)
a <- 3
print(a)

## [1] 3

rm(a)
print(a)</pre>
```

Error in print(a): object 'a' not found

```
a <- 3
print(a)
```

[1] 3

Sauvegarde de tout l'environnement

La commande save.image() enregistre sur disque une copie de l'environnement complet, c'est-à-dire tous les objets existant dans l'espace mémoire de R.

```
# sauvegarde de tout l'environnement, i.e. tous les objets existants
save.image(file="mon_environnement.RData")
```

Suppression de tous les éléments présents dans la session R

Attention, en faisant ceci on perd tout le résultat du travail précédent (chargement des tables de comptage RNA-seq, . . .)

character(0)

load("mon_environnement.RData")

[6] "f" ## [7] "1"

[5]

[4] "d2"

"dir.tuto"

- ## [8] "11"
- ## [9] "12"
- ## [10] "m"
- ## [11] "ma_nouvelle_variable_avec_un_nom_a_rallonge"
- ## [12] "mat1"
- ## [13] "mat2"
- ## [14] "mentions"
- ## [15] "n"
- ## [16] "resultat"
- ## [17] "rna"
- ## [18] "rna2"
- ## [19] "u"
- ## [20] "v"
- ## [21] "w"
- ## [22] "x"
- ## [23] "y"

Sauvegarde d'un objet spécifique

```
# Vérifions le contenu de la variable a print(a)
```

[1] 3

```
# sauvegarde d'un objet spécifique
save(a, file="objet_a.RData")
```

Chargement d'un objet/environnement

```
# Effacçons le contenu de la variable a
rm(a)
print(a)
```

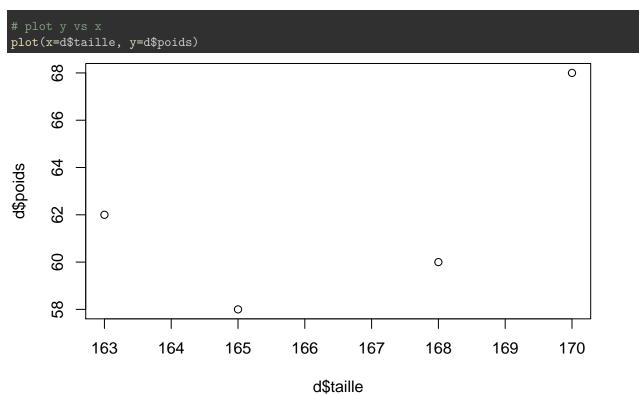
Error in print(a): object 'a' not found

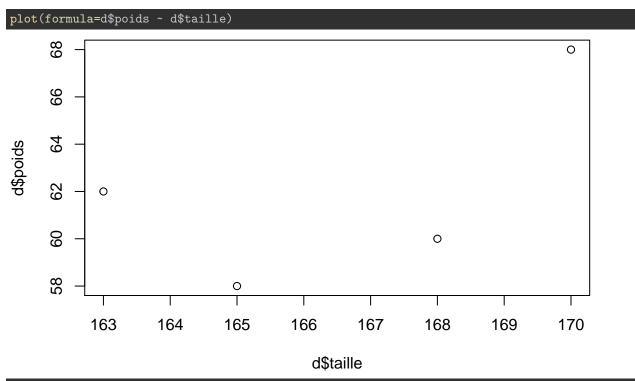
```
# chargement d'un objet/environnement
load("objet_a.RData")
print(a)
```

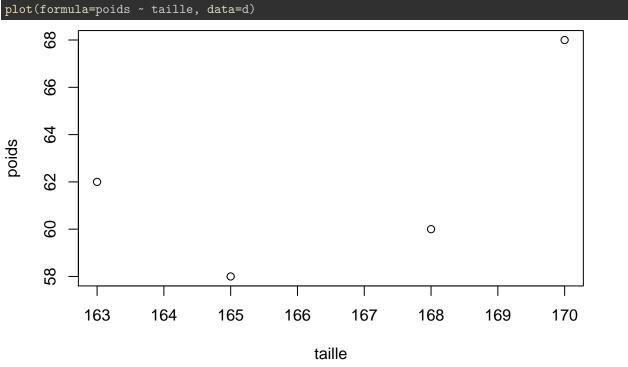
[1] 3

Graphiques

Nuage de points (XY plot)

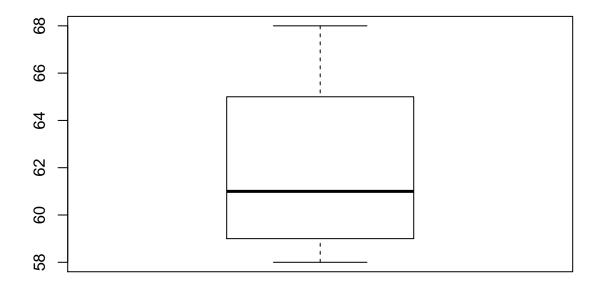






Boîte à moustaches (boxplot)

boite à moustache d'une série de valeurs
boxplot(d\$poids)



Histogramme

histogramme d'une série de valeurs hist(d\$poids)

Histogram of d\$poids

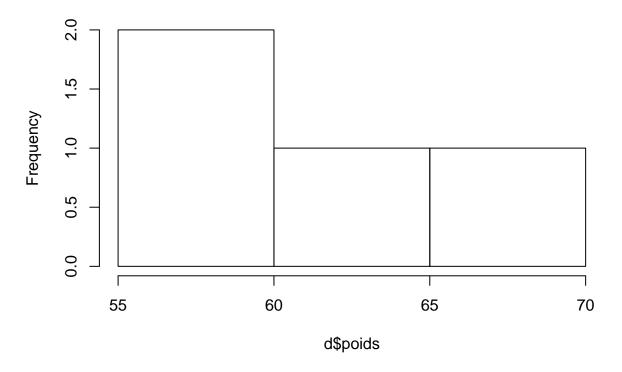
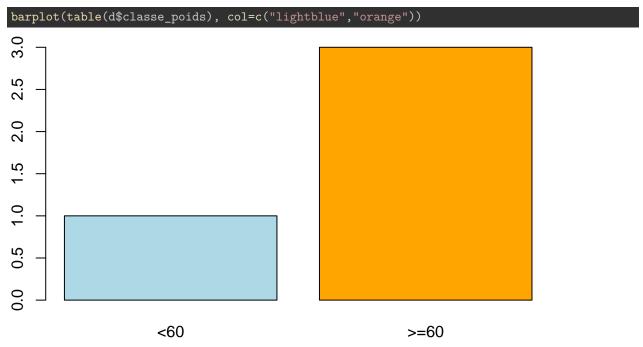


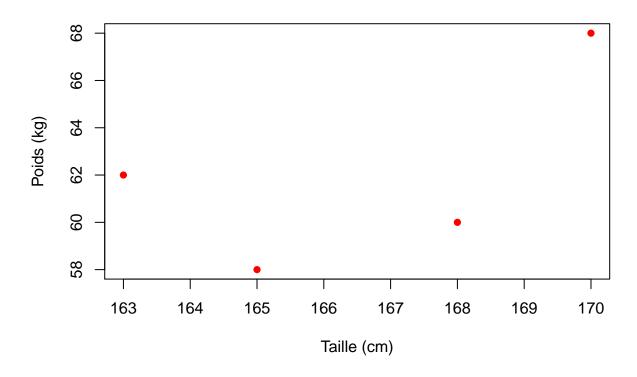
Diagramme en bâtons (barplot)

diagramme en bâtons
table(d\$classe_poids)



Personnalisation des graphiques

Poids vs taille de 4 individus



Couleurs disponibles

liste des couleurs disponibles colors()

##	[1]	"white"	"aliceblue"	"antiquewhite"
##	[4]	"antiquewhite1"	"antiquewhite2"	"antiquewhite3"
##	[7]	"antiquewhite4"	"aquamarine"	"aquamarine1"
##	[10]	"aquamarine2"	"aquamarine3"	"aquamarine4"
##	[13]	"azure"	"azure1"	"azure2"
##	[16]	"azure3"	"azure4"	"beige"
##	[19]	"bisque"	"bisque1"	"bisque2"
##	[22]	"bisque3"	"bisque4"	"black"
##	[25]	"blanchedalmond"	"blue"	"blue1"
##	[28]	"blue2"	"blue3"	"blue4"
##	[31]	"blueviolet"	"brown"	"brown1"
##	[34]	"brown2"	"brown3"	"brown4"
##	[37]	"burlywood"	"burlywood1"	"burlywood2"
##	[40]	"burlywood3"	"burlywood4"	"cadetblue"
##	[43]	"cadetblue1"	"cadetblue2"	"cadetblue3"
##	[46]	"cadetblue4"	"chartreuse"	"chartreuse1"
##	[49]	"chartreuse2"	"chartreuse3"	"chartreuse4"
##	[52]	"chocolate"	"chocolate1"	"chocolate2"
##	[55]	"chocolate3"	"chocolate4"	"coral"
##	[58]	"coral1"	"coral2"	"coral3"
##	[61]	"coral4"	"cornflowerblue"	"cornsilk"
##	[64]	"cornsilk1"	"cornsilk2"	"cornsilk3"
##	[67]	"cornsilk4"	"cyan"	"cyan1"
			•	•

## [73] "darkblue" "darkcyan" "darkgoldenrod" ## [76] "darkgoldenrod1" "darkgoldenrod2" "darkgoldenrod3" ## [79] "darkgoldenrod4" "darkgray" "darkgreen" ## [82] "darkgrey" "darkkhaki" "darkmagenta" ## [85] "darkolivegreen" "darkolivegreen1" "darkolivegreen2" ## [88] "darkolivegreen3" "darkolivegreen4" "darkorange" ## [91] "darkorange1" "darkorange2" "darkorange3" ## [94] "darkorange4" "darkorchid1" "darkorchid1" ## [97] "darkorchid2" "darkorchid3" "darkorchid4" ## [100] "darkred" "darksalmon" "darkseagreen1" ## [103] "darkseagreen1" "darkseagreen2" "darkslategray"	##	[70]	"cyan2"	"cyan3"	"cyan4"
## [76] "darkgoldenrod1" "darkgray" "darkgoldenrod3" ## [79] "darkgoldenrod4" "darkgray" "darkgreen" ## [82] "darkgrey" "darkhaki" "darkmagenta" ## [88] "darkolivegreen" "darkolivegreen1" "darkolivegreen2" ## [88] "darkolivegreen3" "darkolivegreen4" "darkorange3" ## [94] "darkorange4" "darkorange2" "darkorchid1" ## [97] "darkorchid2" "darkorchid3" "darkorchid4" ## [100] "darkred1" "darksalmon" "darkseagreen3" ## [103] "darkseagreen1" "darkseagreen2" "darkseagreen3" ## [109] "darkslategray1" "darkslateblue" "darkslategray3" ## [112] "darkslategray4" "darkslategray2" "darkslategray3" ## [112] "darkslategray4" "darkslategray9" "darkslategray3" ## [112] "deepskyblue1" "deepskyblue4" "deepskyblue4" ## [121] "deepskyblue6" "deepskyblue4" "dargay3" ## [122] "deipskyblue6" "deepskyblue4" "dimgray3" ## [133] "firebrick" "firebrick1" "firebrick2" ## [133] "firebrick" "firebrick1" "firebrick2" ## [133] "firebrick" "firebrick1" "firebrick2" ## [148] "gold3" "gold4" "gold1" "gold2" ## [148] "gold5" "gold4" "gold1" "gold2" ## [148] "gray1" "gray2" "gray0" ## [149] "gray1" "gray2" "gray0" ## [160] "gray7" "gray2" "gray0" ## [161] "gray4" "gray2" "gray0" ## [162] "gray10" "gray11" "gray12" ## [163] "gray10" "gray11" "gray12" ## [164] "gray11" "gray2" "gray0" ## [165] "gray2" "gray3" "gray0" ## [166] "gray7" "gray2" "gray3" ## [167] "gray4" "gray2" "gray0" ## [168] "gray10" "gray11" "gray15" ## [169] "gray16" "gray22" "gray27" "gray3" ## [169] "gray16" "gray22" "gray33" "gray34" ## [169] "gray16" "gray20" "gray31" "gray42" ## [169] "gray40" "gray20" "gray33" "gray34" ## [169] "gray40" "gray32" "gray36" "gray36" ## [169] "gray40" "gray40" "gray36" "gray36" ## [169] "gray40" "gray50" "gray36" "gray36" ## [160] "gray70" "gray40" "gray40" "gray40" ## [160] "gray70" "gray66" "gray56" "gray56" ## [160] "gray70" "gray66" "gray66" "gray66" ## [200] "gray67" "gray71" "gray72" "gray66" ## [200] "gray67" "gray66" "gray66" "gray66" ## [200] "gray77" "gray71" "gray71" "gray72"	##		= -	=	
## [79] "darkgoldenrod4" "darkgray" "darkgreen" ## [88] "darkolivegreen" "darkhaki" "darkmagenta" ## [88] "darkolivegreen" "darkolivegreen1" "darkorange" ## [88] "darkolivegreen3" "darkolivegreen4" "darkorange8" ## [91] "darkorange4" "darkorande2" "darkorange8" ## [94] "darkorange4" "darkorchid3" "darkorchid1" ## [97] "darkorchid2" "darkorchid3" "darkorchid4" ## [100] "darked" "darksalmon" "darkseagreen3" ## [103] "darkseagreen1" "darkslateblue" "darkslategray1" ## [109] "darkslategray1" "darkslategray2" "darkslategray3" ## [112] "darkslategray4" "darkslategray2" "darkslategray3" ## [118] "deeppink2" "deeppink3" "deeppink1" ## [118] "deeppink2" "deeppink3" "deeppink1" ## [124] "deepskyblue8" "deepskyblue1" "deepskyblue2" ## [124] "deepskyblue3" "deepskyblue4" "dimgray1" ## [130] "dodgerblue2" "dodgerblue4" "dimgray1" ## [131] "dodgerblue2" "dodgerblue4" "dimgray1" ## [133] "firebrick1" "firebrick1" "firebrick2" ## [136] "firebrick3" "firebrick1" "firebrick2" ## [136] "firebrick3" "firebrick4" "floralwhite" ## [145] "gold3" "gold4" "gold4" "goldenrod3" ## [145] "gold3" "gold4" "gold4" "goldenrod3" ## [145] "gray4" "gray5" "gray6" ## [160] "gray7" "gray6" "gray6" ## [161] "gray10" "gray11" "gray12" ## [161] "gray20" "gray30" "gray30" ## [161] "gray20" "gray30" "gray30" ## [161] "gray10" "gray11" "gray12" ## [161] "gray20" "gray30" "gray30" ## [161] "gray40" "gray30" "gray30" "gray30" ## [161] "gray40" "gray30" "gray30" "gray30" ## [181] "gray40" "gray50" "gray30" "gray30" ## [190] "gray40" "gray50" "gray30" "gray40" ## [190] "gray40" "gray50" "gray30" "gray40" ## [190] "gray40" "gray50" "gray50" "gray60" ## [1211] "gray60" "gray60" "gray66" "gray60" ## [220] "gray60" "gray66" "gray66" "gray60" ## [220] "gray67" "gray66" "gray66" "	##	[76]	"darkgoldenrod1"	"darkgoldenrod2"	"darkgoldenrod3"
## [85] "darkolivegreen" "darkolivegreen1" "darkorangeen2" ## [891] "darkorange1" "darkorange2" "darkorange3" ## [94] "darkorange4" "darkorange2" "darkorange3" ## [94] "darkorange4" "darkorchid3" "darkorchid1" ## [97] "darkorchid2" "darkorchid3" "darkorchid4" ## [103] "darkeed" "darksalmon" "darkseagreen3" ## [106] "darkseagreen1" "darkslateblue" "darkslategray3" ## [109] "darkslategray1" "darkslateblue" "darkslategray3" ## [1112] "darkslategray4" "darkslategray2" "darkslategray3" ## [1115] "darkviolet" "deeppink1" "deeppink1" ## [121] "deepskyblue1" "deeppink3" "deeppink1" ## [124] "deepskyblue3" "deepskyblue1" "deepskyblue2" ## [127] "dimgrey" "dodgerblue1" "dodgerblue1" ## [133] "firebrick1" "firebrick1" "firebrick2" ## [133] "firebrick8" "firebrick1" "firebrick2" ## [133] "firebrick3" "firebrick4" "floralwhite1" ## [148] "gold3" "gold4" "gold2" ## [148] "gold3" "gold4" "goldenrod3" ## [148] "gray1" "gray2" "gray0" ## [151] "gray4" "gray2" "gray0" ## [163] "gray7" "gray6" "gray7" "gray0" ## [163] "gray10" "gray11" "gray12" "gray12" ## [163] "gray10" "gray14" "gray12" "gray18" ## [163] "gray20" "gray33" "gray4" "gray20" "gray30" ## [164] "gray13" "gray20" "gray31" "gray4" "gray21" "gray12" "gray12" "gray12" "gray12" "gray12" "gray12" "gray12" "gray14" "gray12" "gray14" "gray15" "gray28" "gray30" "gray30" "gray30" "gray44" "gray30" "gray30" "gray30" "gray44" "gray30" "gray44" "gray35" "gray36" "gray36" "gray37" "gray46" "gray35" "gray36" "gray36" "gray36" "gray46" "gray45" "gray46" "gray45" "gray50" "gray60" "gray46" "gray50" "gray60" "gray77" "gray66" "gray66" "gray77" "gray66" "gray77" "gray66" "gray77" "gray66" "gray77	##	[79]	"darkgoldenrod4"	"darkgray"	"darkgreen"
## [88] "darkolivegreen3"	##	[82]	"darkgrey"	"darkkhaki"	"darkmagenta"
## [88] "darkolivegreen3"	##	[85]	"darkolivegreen"	"darkolivegreen1"	"darkolivegreen2"
## [94] "darkorange4" "darkorchid" "darkorchid1" ## [97] "darkorchid2" "darkorchid3" "darkorchid4" ## [100] "darkred" "darksalmon" "darkseagreen" ## [103] "darkseagreen1" "darkseagreen2" "darkseagreen3" ## [106] "darkseagreen4" "darkslateblue" "darkslategray3" ## [109] "darkslategray1" "darkslategray2" "darkslategray3" ## [112] "darkslategray4" "darkslategray2" "darkslategray3" ## [115] "darkviolet" "deeppink3" "deeppink1" ## [118] "deeppink2" "deeppink3" "deeppink4" ## [121] "deepskyblue" "deepskyblue4" "dimgray" ## [127] "dimgrey" "dodgerblue4" "dimgray" ## [130] "dodgerblue2" "dodgerblue4" "dimgray1" ## [130] "firebrick8" "firebrick1" "firebrick2" ## [133] "firebrick8" "firebrick4" "filoralwhite" ## [136] "firebrick3" "gainsboro" "ghostwhite" ## [148] "gold3" "gold4" "gold1" "gold2" ## [148] "goldderrod1" "golderrod2" "golderrod3" ## [151] "gray4" "gray2" "gray3" ## [151] "gray4" "gray5" "gray6" ## [160] "gray7" "gray8" "gray9" ## [161] "gray10" "gray11" "gray12" ## [162] "gray10" "gray11" "gray12" ## [163] "gray10" "gray11" "gray12" ## [164] "gray10" "gray11" "gray12" ## [165] "gray20" "gray30" "gray16" ## [178] "gray20" "gray30" "gray16" ## [178] "gray20" "gray30" "gray24" ## [179] "gray20" "gray30" "gray24" ## [179] "gray20" "gray30" "gray16" "gray16" "gray17" "gray18" ## [181] "gray28" "gray29" "gray30" ## [184] "gray28" "gray29" "gray30" ## [184] "gray28" "gray39" "gray49" "gray30" ## [186] "gray40" "gray40" "gray41" "gray18" ## [187] "gray40" "gray50" "gray30" "gray44" ## [188] "gray40" "gray50" "gray30" "gray45" ## [199] "gray46" "gray50" "gray50" "gray48" ## [190] "gray50" "gray50" "gray50" "gray60" ## [200] "gray50" "gray50" "gray60" "gray60" ## [200] "gray66" "gray66" "gray66" "gray60" ## [200] "gray66" "gray66" "gray60" ## [200] "gray66" "gray66" "gray60" ## [200] "gray60" "gray60" "gray60" ## [200] "gray60" "gray71" "gray60" ## [200] "gray60" "gray60" "gray60" ## [200] "gray60" "gray71" "gray60"	##	[88]		"darkolivegreen4"	"darkorange"
## [97] "darkorchid2" "darkorchid3" "darkorchid4" ## [100] "darkred" "darksalmon" "darkseagreen1" ## [106] "darkseagreen1" "darkseagreen2" "darkseagreen3" ## [106] "darkseagreen4" "darkslateblue" "darkslategray7" ## [109] "darkslategray4" "darkslategray2" "darkslategray8" ## [112] "darkslategray4" "darkslategray7" "darkslategray8" ## [115] "darkviolet" "deeppink8" "deeppink4" ## [118] "deepskyblue" "deepskyblue1" "deepskyblue2" ## [121] "deepskyblue3" "deepskyblue1" "deepskyblue2" ## [127] "dimgrey" "dodgerblue" "dodgerblue1" ## [130] "dodgerblue2" "dodgerblue3" "dodgerblue4" ## [133] "firebrick7" "firebrick1" "firebrick7" "firebrick8" "forebrick1" "firebrick8" ## [139] "forestgreen" "gainsboro" "ghostwhite" "gold2" ## [148] "goldar041" "gold1" "gold2" "goldenrod3" "goldenrod3" "goldenrod3" "gray7" "gray0" ## [151] "goldenrod4" "gray1" "gray0" "gray0" ## [166] "gray7" "gray8" "gray9" "gray9" ## [166] "gray10" "gray11" "gray12" "gray18" ## [178] "gray16" "gray17" "gray21" "gray18" ## [178] "gray22" "gray33" "gray24" "gray33" "gray34" "gray31" "gray39" "gray30" "gray27" "gray30" "gray30" "gray27" "gray30" "gray31" "gray30" "gray31" "gray19" "gray30" "gray21" "gray30" "gray30" "gray21" "gray30" "gray21" "gray30" "gray21" "gray30" "gray21" "gray30" "gray21" "gray30" "gray24" "gray30" "gray24" "gray30" "gray24" "gray30" "gray27" "gray30" "gray30" "gray30" "gray30" "gray30" "gray30" "gray44" "gray32" "gray30" "gray30" "gray30" "gray30" "gray30" "gray30" "gray44" "gray30" "gray30" "gray30" "gray30" "gray30" "gray30" "gray44" "gray30" "gray45" "gray30" "gray45" "gray30" "gray45" "gray46" "gray55" "gray56" "gray56" "gray56" "gray66" "gray57" "gray66" "gray77" "gray77" "gray66" "gray66" "gray66" "gray66" "gray66" "gray66" "gray66" "gray77" "gray76" "gray66" "gray77" "gray76" "gray76" "gray66" "gray77" "gray76" "gray66" "gray76" "gray66" "gray77	##	[91]	"darkorange1"	"darkorange2"	"darkorange3"
## [100] "darkred" "darksalmon" "darkseagreen" ## [103] "darkseagreen1" "darkseagreen2" "darkseagreen3" ## [106] "darkslategray1" "darkslateblue" "darkslategray3" ## [119] "darkslategray1" "darkslategray2" "darkslategray3" ## [1112] "darkslategray4" "darkslategray2" "darkslategray3" ## [1113] "darkviolet" "deeppink4" "deeppink1" ## [1113] "deepskyblue1" "deeppink8" "deeppink1" ## [121] "deepskyblue3" "deepskyblue4" "dimgray" ## [127] "dimgrey" "dodgerblue4" "dimgray" ## [130] "dodgerblue2" "dodgerblue4" "dimgray" ## [133] "firebrick8" "firebrick1" "firebrick2" ## [133] "firebrick8" "firebrick4" "floralwhite" ## [142] "gold" "gold1" "gold2" ## [143] "gold3" "gold4" "goldenrod3" ## [144] "golda" "gold4" "goldenrod3" ## [145] "gold3" "gold4" "goldenrod3" ## [151] "gray1" "gray2" "gray3" ## [151] "gray1" "gray2" "gray3" ## [160] "gray7" "gray1" "gray2" ## [161] "gray10" "gray11" "gray12" ## [162] "gray13" "gray14" "gray15" ## [163] "gray16" "gray14" "gray15" ## [164] "gray19" "gray20" "gray318" ## [175] "gray22" "gray33" "gray24" ## [175] "gray25" "gray36" "gray27" ## [184] "gray25" "gray36" "gray36" ## [184] "gray25" "gray36" "gray37" ## [184] "gray25" "gray36" "gray37" ## [185] "gray46" "gray35" "gray36" ## [180] "gray46" "gray35" "gray36" ## [181] "gray46" "gray55" "gray36" "gray48" ## [190] "gray46" "gray56" "gray57" ## [190] "gray46" "gray56" "gray57" ## [201] "gray66" "gray57" "gray66" ## [202] "gray66" "gray57" "gray66" "gray60" ## [211] "gray64" "gray66" "gray69" ## [220] "gray67" "gray66" "gray69" ## [220] "gray67" "gray74" "gray69"	##	[94]	"darkorange4"	"darkorchid"	"darkorchid1"
## [103] "darkseagreen1"	##	[97]	"darkorchid2"	"darkorchid3"	"darkorchid4"
## [106] "darkseagreen4" "darkslateblue" "darkslategray" ## [109] "darkslategray1" "darkslategray2" "darkslategray3" ## [112] "darkslategray4" "darkslategrey" "darkturquoise" ## [115] "darkviolet" "deeppink" "deeppink1" ## [118] "deeppink2" "deeppink3" "deeppink4" ## [121] "deepskyblue" "deepskyblue4" "dimgray1" ## [121] "deepskyblue3" "deepskyblue4" "dimgray1" ## [130] "dodgerblue2" "dodgerblue4" "dimgray1" ## [133] "firebrick" "firebrick1" "firebrick2" ## [133] "firebrick3" "firebrick4" "floralwhite" ## [143] "forestgreen" "gainsboro" "ghostwhite" ## [142] "gold" "gold4" "gold2" ## [145] "gold3" "gold4" "goldenrod2" "goldenrod3" ## [154] "gray1" "gray2" "gray0" ## [154] "gray1" "gray2" "gray0" ## [160] "gray7" "gray8" "gray6" ## [160] "gray7" "gray8" "gray9" ## [161] "gray16" "gray11" "gray12" ## [161] "gray16" "gray11" "gray12" ## [161] "gray16" "gray17" "gray21" ## [161] "gray22" "gray31" "gray18" ## [172] "gray19" "gray20" "gray21" ## [181] "gray25" "gray33" "gray24" ## [181] "gray25" "gray30" "gray24" ## [181] "gray28" "gray30" "gray24" ## [181] "gray28" "gray30" "gray30" ## [181] "gray46" "gray35" "gray30" ## [181] "gray40" "gray35" "gray30" ## [181] "gray40" "gray35" "gray30" ## [181] "gray40" "gray35" "gray36" ## [190] "gray37" "gray38" "gray30" ## [181] "gray40" "gray41" "gray15" ## [181] "gray40" "gray50" "gray37" "gray38" ## [181] "gray40" "gray50" "gray37" "gray36" ## [190] "gray41" "gray45" "gray37" "gray45" ## [190] "gray40" "gray50" "gray50" "gray50" ## [191] "gray46" "gray50" "gray50" "gray57" ## [202] "gray40" "gray50" "gray50" "gray57" ## [203] "gray58" "gray56" "gray66" ## [204] "gray60" "gray60" "gray60" ## [211] "gray60" "gray60" "gray60" ## [221] "gray60" "gray60" "gray60" ## [222] "gray70" "gray71" "gray60"	##	[100]	"darkred"	"darksalmon"	"darkseagreen"
## [109] "darkslategray1" "darkslategray2" "darkslategray3" ## [112] "darkslategray4" "darkslategrey" "darkturquoise" ## [115] "darkviolet" "deeppink" "deeppink1" ## [118] "deeppink2" "deeppink3" "deeppink1" ## [121] "deepskyblue1" "deepskyblue4" "dimgray" ## [124] "deepskyblue3" "deepskyblue4" "dimgray" ## [127] "dimgrey" "dodgerblue0" "dodgerblue1" ## [130] "dodgerblue2" "dodgerblue3" "dodgerblue4" ## [133] "firebrick1" "firebrick4" "floralwhite" ## [136] "firebrick3" "firebrick4" "floralwhite" ## [142] "gold0" "gold1" "gold2" ## [145] "gold3" "gold4" "goldenrod2" "goldenrod3" ## [148] "goldenrod4" "gray2" "gray3" ## [157] "gray4" "gray2" "gray0" ## [160] "gray7" "gray8" "gray6" ## [168] "gray10" "gray11" "gray12" ## [169] "gray16" "gray14" "gray12" "gray18" ## [172] "gray19" "gray20" "gray18" ## [173] "gray22" "gray31" "gray12" ## [175] "gray49# "gray20" "gray18" ## [176] "gray21" "gray21" "gray18" ## [177] "gray19" "gray20" "gray21" ## [178] "gray21" "gray22" "gray30" ## [181] "gray22" "gray33" "gray27" ## [181] "gray28" "gray30" "gray27" ## [181] "gray28" "gray30" "gray30" ## [181] "gray37" "gray32" "gray30" ## [181] "gray28" "gray38" "gray39" ## [181] "gray28" "gray39" "gray30" ## [181] "gray37" "gray38" "gray38" "gray39" ## [181] "gray28" "gray38" "gray30" ## [181] "gray28" "gray38" "gray38" "gray36" ## [181] "gray28" "gray38" "gray38" "gray38" ## [181] "gray28" "gray38" "gray30" ## [181] "gray37" "gray38" "gray38" "gray38" ## [182] "gray40" "gray38" "gray38" "gray38" ## [183] "gray40" "gray38" "gray38" "gray38" ## [184] "gray48" "gray56" "gray56" "gray57" ## [185] "gray58" "gray56" "gray57" ## [190] "gray58" "gray56" "gray56" "gray69" ## [201] "gray61" "gray66" "gray66" ## [202] "gray61" "gray66" "gray69" ## [203] "gray70" "gray70" "gray68" "gray69" ## [204] "gray70" "gray71" "gray75"	##	[103]	"darkseagreen1"	"darkseagreen2"	"darkseagreen3"
## [112] "darkslategray4" "darkslategrey" "darkturquoise" ## [118] "darkviolet" "deeppink" "deeppink1" ## [118] "deeppink2" "deeppink3" "deeppink4" ## [121] "deepskyblue" "deepskyblue1" "deepskyblue2" ## [124] "deepskyblue3" "deepskyblue4" "dimgray" ## [127] "dimgrey" "dodgerblue4" "dodgerblue1" ## [130] "dodgerblue2" "dodgerblue3" "dodgerblue4" ## [133] "firebrick" "firebrick1" "firebrick2" ## [136] "firebrick3" "firebrick4" "floralwhite" ## [148] "gold" "gold4" "gold4" ## [148] "golds" "gold4" "goldenrod" ## [148] "goldenrod1" "goldenrod2" "goldenrod3" ## [151] "goldenrod4" "gray0" "gray0" ## [157] "gray4" "gray2" "gray3" ## [160] "gray7" "gray8" "gray9" ## [163] "gray10" "gray11" "gray12" ## [169] "gray16" "gray14" "gray15" ## [172] "gray19" "gray20" "gray15" ## [173] "gray19" "gray20" "gray18" ## [174] "gray22" "gray21" "gray21" ## [175] "gray19" "gray20" "gray10" ## [181] "gray22" "gray33" "gray14" "gray21" ## [178] "gray20" "gray21" "gray21" ## [179] "gray19" "gray20" "gray21" ## [170] "gray10" "gray11" "gray21" ## [1718] "gray20" "gray21" "gray21" ## [181] "gray20" "gray21" "gray30" "gray30" ## [181] "gray20" "gray30" "gray30" ## [181] "gray20" "gray30" "gray30" ## [181] "gray20" "gray30" "gray30" ## [181] "gray31" "gray32" "gray30" ## [181] "gray40" "gray31" "gray38" "gray39" ## [190] "gray37" "gray38" "gray39" "gray46" ## [190] "gray46" "gray46" "gray46" "gray45" ## [190] "gray40" "gray50" "gray46" ## [190] "gray40" "gray50" "gray46" ## [190] "gray46" "gray50" "gray60" ## [201] "gray60" "gray60" "gray60" ## [214] "gray61" "gray60" "gray60" ## [220] "gray60" "gray60" "gray60" ## [221] "gray60" "gray60" "gray60" ## [220] "gray70" "gray60" "gray60" ## [220] "gray70" "gray60" "gray60" ## [220] "gray70" "gray74" "gray75"	##	[106]	"darkseagreen4"	"darkslateblue"	"darkslategray"
## [115] "darkviolet" "deeppink" "deeppink1" ## [118] "deepskyblue" "deepskyblue1" "deepskyblue2" ## [121] "deepskyblue3" "deepskyblue4" "dimgray" ## [127] "dimgrey" "dodgerblue" "dodgerblue4" ## [130] "dodgerblue2" "dodgerblue3" "dodgerblue4" ## [133] "firebrick8" "firebrick1" "firebrick2" ## [136] "firebrick3" "firebrick4" "floralwhite" ## [139] "forestgreen" "gainsboro" "ghostwhite" ## [142] "gold0" "gold1" "gold2" ## [145] "gold3" "gold4" "goldenrod2" "goldenrod3" ## [151] "goldenrod1" "gray7" "gray0" ## [151] "goldenrod4" "gray7" "gray0" ## [157] "gray4" "gray5" "gray5" "gray6" ## [168] "gray10" "gray11" "gray12" ## [169] "gray10" "gray17" "gray18" ## [172] "gray19" "gray20" "gray18" ## [173] "gray22" "gray21" "gray18" ## [174] "gray22" "gray39" "gray21" ## [181] "gray22" "gray39" "gray12" ## [181] "gray22" "gray3" "gray24" ## [178] "gray22" "gray23" "gray24" ## [181] "gray28" "gray29" "gray30" ## [181] "gray31" "gray29" "gray30" ## [181] "gray31" "gray29" "gray30" ## [181] "gray31" "gray32" "gray30" ## [181] "gray34" "gray35" "gray36" ## [190] "gray37" "gray38" "gray36" ## [190] "gray40" "gray41" "gray42" ## [191] "gray40" "gray47" "gray48" ## [202] "gray49" "gray50" "gray50" "gray51" ## [203] "gray55" "gray55" "gray60" ## [211] "gray64" "gray59" "gray60" ## [221] "gray61" "gray62" "gray60" ## [221] "gray61" "gray71" "gray60" ## [221] "gray61" "gray71" "gray60" ## [222] "gray67" "gray68" "gray59" "gray60" ## [223] "gray67" "gray60" "gray71" "gray60" ## [223] "gray67" "gray60" "gray71" "gray60" ## [224] "gray61" "gray60" "gray71" "gray60" ## [225] "gray70" "gray71" "gray60" ## [226] "gray70" "gray71" "gray77"	##	[109]	"darkslategray1"	"darkslategray2"	"darkslategray3"
## [118] "deeppink2" "deeppink3" "deeppink4" ## [121] "deepskyblue" "deepskyblue4" "dimgray" ## [121] "deepskyblue3" "deepskyblue4" "dimgray" ## [127] "dimgrey" "dodgerblue" "dodgerblue1" ## [130] "dodgerblue2" "dodgerblue3" "dodgerblue4" ## [133] "firebrick" "firebrick1" "firebrick2" ## [136] "firebrick3" "firebrick4" "floralwhite" ## [139] "forestgreen" "gainsboro" "ghostwhite" ## [142] "gold" "gold1" "gold2" ## [145] "gold3" "gold4" "goldenrod1" ## [151] "goldenrod1" "gray0" "gray0" ## [151] "goldenrod4" "gray" "gray0" ## [157] "gray4" "gray5" "gray6" ## [160] "gray7" "gray8" "gray9" ## [163] "gray10" "gray11" "gray12" ## [163] "gray10" "gray11" "gray12" ## [166] "gray13" "gray14" "gray12" ## [168] "gray16" "gray17" "gray18" ## [172] "gray19" "gray20" "gray18" ## [173] "gray25" "gray20" "gray21" ## [175] "gray25" "gray20" "gray21" ## [178] "gray25" "gray26" "gray27" ## [181] "gray28" "gray29" "gray30" ## [181] "gray31" "gray32" "gray30" ## [181] "gray34" "gray32" "gray33" ## [187] "gray34" "gray35" "gray36" ## [190] "gray37" "gray38" "gray39" ## [190] "gray40" "gray44" "gray45" ## [190] "gray40" "gray50" "gray48" ## [190] "gray40" "gray50" "gray48" ## [190] "gray40" "gray50" "gray48" ## [190] "gray40" "gray50" "gray45" ## [190] "gray40" "gray50" "gray45" ## [190] "gray40" "gray50" "gray51" ## [190] "gray40" "gray50" "gray45" ## [190] "gray55" "gray50" "gray45" ## [201] "gray55" "gray56" "gray57" ## [202] "gray40" "gray50" "gray57" ## [203] "gray55" "gray66" "gray50" ## [211] "gray68" "gray50" "gray60" ## [222] "gray60" "gray60" ## [223] "gray60" "gray60" ## [220] "gray67" "gray68" "gray60" ## [220] "gray67" "gray68" "gray69" ## [220] "gray70" "gray71" "gray75"	##	[112]	"darkslategray4"	"darkslategrey"	"darkturquoise"
## [118] "deeppink2" "deeppink3" "deeppink4" ## [121] "deepskyblue" "deepskyblue4" "dimgray" ## [121] "deepskyblue3" "deepskyblue4" "dimgray" ## [127] "dimgrey" "dodgerblue" "dodgerblue1" ## [130] "dodgerblue2" "dodgerblue3" "dodgerblue4" ## [133] "firebrick" "firebrick1" "firebrick2" ## [136] "firebrick3" "firebrick4" "floralwhite" ## [139] "forestgreen" "gainsboro" "ghostwhite" ## [142] "gold" "gold1" "gold2" ## [145] "gold3" "gold4" "goldenrod1" ## [151] "goldenrod1" "gray0" "gray0" ## [151] "goldenrod4" "gray" "gray0" ## [157] "gray4" "gray5" "gray6" ## [160] "gray7" "gray8" "gray9" ## [163] "gray10" "gray11" "gray12" ## [163] "gray10" "gray11" "gray12" ## [166] "gray13" "gray14" "gray12" ## [168] "gray16" "gray17" "gray18" ## [172] "gray19" "gray20" "gray18" ## [173] "gray25" "gray20" "gray21" ## [175] "gray25" "gray20" "gray21" ## [178] "gray25" "gray26" "gray27" ## [181] "gray28" "gray29" "gray30" ## [181] "gray31" "gray32" "gray30" ## [181] "gray34" "gray32" "gray33" ## [187] "gray34" "gray35" "gray36" ## [190] "gray37" "gray38" "gray39" ## [190] "gray40" "gray44" "gray45" ## [190] "gray40" "gray50" "gray48" ## [190] "gray40" "gray50" "gray48" ## [190] "gray40" "gray50" "gray48" ## [190] "gray40" "gray50" "gray45" ## [190] "gray40" "gray50" "gray45" ## [190] "gray40" "gray50" "gray51" ## [190] "gray40" "gray50" "gray45" ## [190] "gray55" "gray50" "gray45" ## [201] "gray55" "gray56" "gray57" ## [202] "gray40" "gray50" "gray57" ## [203] "gray55" "gray66" "gray50" ## [211] "gray68" "gray50" "gray60" ## [222] "gray60" "gray60" ## [223] "gray60" "gray60" ## [220] "gray67" "gray68" "gray60" ## [220] "gray67" "gray68" "gray69" ## [220] "gray70" "gray71" "gray75"	##	[115]	"darkviolet"	"deeppink"	"deeppink1"
## [124] "deepskyblue3" "deepskyblue4" "dimgray" ## [127] "dimgrey" "dodgerblue" "dodgerblue1" ## [130] "dodgerblue2" "dodgerblue3" "dodgerblue4" ## [133] "firebrick" "firebrick1" "firebrick2" ## [136] "firebrick3" "firebrick4" "floralwhite" ## [139] "forestgreen" "gainsboro" "ghostwhite" ## [142] "gold3" "gold4" "gold2" ## [145] "gold3" "gold4" "goldenrod4" ## [151] "goldenrod1" "goldenrod2" "goldenrod3" ## [151] "goldenrod4" "gray" "gray0" ## [154] "gray1" "gray2" "gray6" ## [160] "gray7" "gray8" "gray6" ## [161] "gray10" "gray11" "gray11" "gray12" ## [162] "gray13" "gray14" "gray15" ## [172] "gray19" "gray20" "gray15" ## [173] "gray22" "gray21" "gray21" ## [174] "gray22" "gray23" "gray21" ## [175] "gray22" "gray20" "gray21" ## [175] "gray22" "gray20" "gray27" ## [181] "gray25" "gray26" "gray27" ## [184] "gray31" "gray26" "gray27" ## [184] "gray31" "gray32" "gray30" ## [184] "gray31" "gray32" "gray30" ## [184] "gray31" "gray32" "gray30" ## [184] "gray31" "gray35" "gray36" ## [190] "gray37" "gray38" "gray39" "gray36" ## [191] "gray40" "gray41" "gray42" ## [192] "gray40" "gray41" "gray42" ## [193] "gray40" "gray50" "gray50" "gray51" ## [202] "gray49" "gray50" "gray50" "gray51" ## [203] "gray55" "gray56" "gray50" "gray51" ## [204] "gray55" "gray50" "gray50" "gray51" ## [205] "gray55" "gray56" "gray50" "gray51" ## [207] "gray58" "gray50" "gray50" "gray60" ## [211] "gray64" "gray50" "gray50" "gray60" ## [212] "gray61" "gray60" "gray60" ## [211] "gray61" "gray60" "gray60" ## [212] "gray61" "gray68" "gray60" ## [211] "gray61" "gray60" "gray60" ## [222] "gray67" "gray68" "gray60" ## [223] "gray70" "gray68" "gray60" ## [226] "gray70" "gray68" "gray60" ## [226] "gray70" "gray68" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##	[118]	"deeppink2"		"deeppink4"
## [127] "dimgrey" "dodgerblue" "dodgerblue1" ## [130] "dodgerblue2" "dodgerblue3" "dodgerblue4" ## [133] "firebrick4" "firebrick4" "firebrick2" ## [136] "firebrick3" "firebrick4" "floralwhite" ## [139] "forestgreen" "gainsboro" "ghostwhite" ## [142] "gold" "gold1" "gold2" ## [145] "gold3" "gold4" "goldenrod4" ## [148] "goldenrod4" "gray" "gray0" ## [151] "gray1" "gray2" "gray3" ## [157] "gray4" "gray5" "gray6" ## [160] "gray7" "gray8" "gray6" ## [161] "gray10" "gray11" "gray12" ## [163] "gray10" "gray11" "gray12" ## [169] "gray16" "gray17" "gray18" ## [172] "gray29" "gray29" "gray21" ## [175] "gray22" "gray29" "gray24" ## [178] "gray25" "gray20" "gray27" ## [184] "gray31" "gray29" "gray24" ## [187] "gray34" "gray29" "gray30" ## [184] "gray31" "gray32" "gray30" ## [187] "gray31" "gray32" "gray33" ## [187] "gray34" "gray35" "gray36" ## [190] "gray37" "gray38" "gray44" "gray45" ## [199] "gray46" "gray44" "gray45" ## [199] "gray46" "gray47" "gray48" ## [202] "gray49" "gray50" "gray51" ## [205] "gray55" "gray56" "gray56" "gray56" ## [211] "gray58" "gray59" "gray60" ## [211] "gray64" "gray59" "gray66" ## [220] "gray67" "gray66" "gray66" ## [220] "gray67" "gray68" "gray69" ## [220] "gray70" "gray68" "gray69" ## [220] "gray70" "gray71" "gray72" ## [220] "gray70" "gray68" "gray69" ## [220] "gray70" "gray68" "gray69" ## [220] "gray70" "gray71" "gray69"	##	[121]	"deepskyblue"	"deepskyblue1"	"deepskyblue2"
## [130] "dodgerblue2" "dodgerblue3" "dodgerblue4" ## [133] "firebrick" "firebrick1" "firebrick2" ## [139] "forestgreen" "gainsboro" "ghostwhite" ## [142] "gold" "gold4" "goldenrod1" ## [143] "goldenrod1" "gray1" "gray0" ## [151] "goldenrod4" "gray1" "gray3" ## [151] "goldenrod4" "gray5" "gray6" ## [163] "gray4" "gray5" "gray6" ## [166] "gray10" "gray11" "gray12" ## [166] "gray10" "gray11" "gray12" ## [167] "gray10" "gray11" "gray12" ## [188] "gray10" "gray14" "gray15" ## [172] "gray10" "gray17" "gray18" ## [173] "gray19" "gray20" "gray21" ## [174] "gray19" "gray20" "gray21" ## [175] "gray22" "gray23" "gray24" ## [178] "gray25" "gray26" "gray27" ## [181] "gray31" "gray32" "gray30" ## [184] "gray31" "gray32" "gray33" "gray30" ## [187] "gray34" "gray35" "gray36" ## [190] "gray40" "gray41" "gray42" ## [191] "gray40" "gray41" "gray42" ## [192] "gray40" "gray41" "gray42" ## [193] "gray40" "gray41" "gray42" ## [194] "gray55" "gray60" "gray51" ## [202] "gray49" "gray50" "gray51" ## [203] "gray50" "gray50" "gray51" ## [204] "gray55" "gray60" "gray57" ## [211] "gray64" "gray62" "gray60" ## [212] "gray67" "gray68" "gray69" ## [222] "gray67" "gray68" "gray72" ## [222] "gray67" "gray68" "gray75" ## [222] "gray67" "gray68" "gray79" ## [222] "gray77" "gray77" "gray72" ## [222] "gray67" "gray68" "gray69" ## [223] "gray770" "gray77" "gray77" "gray77" ## [226] "gray77" "gray77" "gray77"	##	[124]	"deepskyblue3"	"deepskyblue4"	"dimgray"
## [133] "firebrick" "firebrick1" "firebrick2" ## [136] "firebrick3" "firebrick4" "floralwhite" ## [139] "forestgreen" "gainsboro" "ghostwhite" ## [142] "gold" "gold1" "gold2" ## [145] "gold3" "gold4" "goldenrod1" ## [148] "goldenrod1" "goldenrod2" "goldenrod3" ## [151] "goldenrod4" "gray" "gray0" ## [151] "gray1" "gray2" "gray3" ## [167] "gray4" "gray5" "gray6" ## [160] "gray7" "gray8" "gray9" ## [163] "gray10" "gray11" "gray12" ## [166] "gray13" "gray14" "gray15" ## [172] "gray19" "gray20" "gray18" ## [172] "gray19" "gray20" "gray21" ## [173] "gray22" "gray23" "gray24" ## [174] "gray25" "gray26" "gray27" ## [181] "gray28" "gray29" "gray30" ## [184] "gray31" "gray32" "gray30" ## [187] "gray34" "gray32" "gray36" ## [190] "gray37" "gray38" "gray36" ## [190] "gray40" "gray41" "gray42" ## [190] "gray40" "gray41" "gray42" ## [190] "gray46" "gray41" "gray42" ## [190] "gray46" "gray47" "gray48" ## [202] "gray46" "gray50" "gray57" ## [208] "gray55" "gray56" "gray57" ## [211] "gray64" "gray65" "gray66" ## [222] "gray67" "gray68" "gray69" ## [223] "gray77" "gray77" "gray72" ## [222] "gray67" "gray68" "gray69" ## [223] "gray77" "gray72" ## [226] "gray77" "gray77" "gray72" ## [226] "gray77" "gray77" "gray72" ## [226] "gray77" "gray77" "gray72"	##	[127]	"dimgrey"	"dodgerblue"	"dodgerblue1"
## [133] "firebrick" "firebrick1" "firebrick2" ## [136] "firebrick3" "firebrick4" "floralwhite" ## [139] "forestgreen" "gainsboro" "ghostwhite" ## [142] "gold" "gold1" "gold2" ## [145] "gold3" "gold4" "goldenrod1" ## [148] "goldenrod1" "goldenrod2" "goldenrod3" ## [151] "goldenrod4" "gray" "gray0" ## [151] "gray1" "gray2" "gray3" ## [167] "gray4" "gray5" "gray6" ## [160] "gray7" "gray8" "gray9" ## [163] "gray10" "gray11" "gray12" ## [166] "gray13" "gray14" "gray15" ## [172] "gray19" "gray20" "gray18" ## [172] "gray19" "gray20" "gray21" ## [173] "gray22" "gray23" "gray24" ## [174] "gray25" "gray26" "gray27" ## [181] "gray28" "gray29" "gray30" ## [184] "gray31" "gray32" "gray30" ## [187] "gray34" "gray32" "gray36" ## [190] "gray37" "gray38" "gray36" ## [190] "gray40" "gray41" "gray42" ## [190] "gray40" "gray41" "gray42" ## [190] "gray46" "gray41" "gray42" ## [190] "gray46" "gray47" "gray48" ## [202] "gray46" "gray50" "gray57" ## [208] "gray55" "gray56" "gray57" ## [211] "gray64" "gray65" "gray66" ## [222] "gray67" "gray68" "gray69" ## [223] "gray77" "gray77" "gray72" ## [222] "gray67" "gray68" "gray69" ## [223] "gray77" "gray72" ## [226] "gray77" "gray77" "gray72" ## [226] "gray77" "gray77" "gray72" ## [226] "gray77" "gray77" "gray72"	##	[130]	"dodgerblue2"	"dodgerblue3"	"dodgerblue4"
## [139] "forestgreen" "gainsboro" "ghostwhite" ## [142] "gold" "gold1" "gold2" ## [145] "gold3" "gold4" "goldenrod1" ## [148] "goldenrod1" "goldenrod2" "goldenrod3" ## [151] "goldenrod4" "gray" "gray0" ## [154] "gray1" "gray5" "gray6" ## [160] "gray7" "gray8" "gray9" ## [163] "gray10" "gray11" "gray12" ## [166] "gray13" "gray14" "gray15" ## [172] "gray19" "gray20" "gray18" ## [172] "gray19" "gray20" "gray21" ## [178] "gray22" "gray23" "gray21" ## [181] "gray25" "gray26" "gray27" ## [181] "gray28" "gray29" "gray30" ## [184] "gray31" "gray32" "gray33" ## [187] "gray34" "gray35" "gray36" ## [190] "gray37" "gray38" "gray39" ## [196] "gray40" "gray41" "gray42" ## [196] "gray40" "gray44" "gray45" ## [202] "gray49" "gray50" "gray50" "gray51" ## [203] "gray55" "gray50" "gray50" ## [211] "gray64" "gray66" "gray66" ## [217] "gray64" "gray66" "gray66" ## [222] "gray77" "gray77" "gray78" ## [222] "gray67" "gray68" "gray60" ## [222] "gray77" "gray77" "gray77" ## [222] "gray77" "gray77" "gray77"	##	[133]			"firebrick2"
## [142] "gold" "gold1" "gold2" ## [145] "gold3" "gold4" "goldenrod1" ## [148] "goldenrod1" "goldenrod2" "goldenrod3" ## [151] "goldenrod4" "gray" "gray0" ## [151] "goldenrod4" "gray2" "gray3" ## [157] "gray4" "gray5" "gray6" "gray9" ## [160] "gray7" "gray8" "gray1" "gray12" ## [161] "gray10" "gray11" "gray12" ## [162] "gray16" "gray17" "gray18" ## [172] "gray19" "gray20" "gray21" ## [175] "gray22" "gray23" "gray24" ## [178] "gray22" "gray26" "gray27" ## [181] "gray28" "gray26" "gray30" ## [184] "gray31" "gray32" "gray36" ## [190] "gray37" "gray38" "gray36" ## [191] "gray40" "gray41" "gray42" ## [192] "gray40" "gray41" "gray45" ## [193] "gray40" "gray47" "gray45" ## [202] "gray49" "gray50" "gray50" "gray51" ## [203] "gray49" "gray50" "gray50" "gray51" ## [204] "gray64" "gray59" "gray66" ## [211] "gray64" "gray66" "gray66" ## [222] "gray67" "gray68" "gray68" ## [222] "gray77" "gray71" "gray68" ## [222] "gray77" "gray71" "gray72" ## [222] "gray77" "gray77" "gray77" ## [222] "gray77" "gray77" "gray77" ## [222] "gray67" "gray68" "gray60" ## [222] "gray77" "gray77" "gray77"	##	[136]	"firebrick3"	"firebrick4"	"floralwhite"
## [145] "gold3" "gold4" "goldenrod" ## [148] "goldenrod1" "gray" "gray0" ## [151] "goldenrod4" "gray" "gray0" ## [154] "gray1" "gray2" "gray3" ## [157] "gray4" "gray5" "gray6" ## [160] "gray7" "gray8" "gray9" ## [163] "gray10" "gray11" "gray12" ## [166] "gray13" "gray14" "gray15" ## [169] "gray16" "gray17" "gray18" ## [172] "gray19" "gray20" "gray21" ## [175] "gray22" "gray23" "gray24" ## [178] "gray25" "gray26" "gray27" ## [181] "gray28" "gray29" "gray30" ## [184] "gray31" "gray32" "gray33" ## [187] "gray34" "gray32" "gray36" ## [190] "gray37" "gray38" "gray39" ## [190] "gray40" "gray41" "gray42" ## [190] "gray40" "gray44" "gray42" ## [190] "gray49" "gray44" "gray45" ## [190] "gray49" "gray50" "gray51" ## [202] "gray49" "gray56" "gray57" ## [203] "gray58" "gray56" "gray60" ## [211] "gray64" "gray66" "gray69" ## [223] "gray67" "gray68" "gray69" ## [220] "gray67" "gray68" "gray69" ## [223] "gray70" "gray71" "gray72" ## [226] "gray73" "gray77" "gray75"	##	[139]	"forestgreen"	"gainsboro"	"ghostwhite"
## [148] "goldenrod1" "goldenrod2" "goldenrod3" ## [151] "goldenrod4" "gray" "gray0" ## [154] "gray1" "gray2" "gray3" ## [157] "gray4" "gray5" "gray6" ## [160] "gray7" "gray8" "gray9" ## [163] "gray10" "gray11" "gray12" ## [166] "gray13" "gray14" "gray15" ## [169] "gray16" "gray17" "gray18" ## [172] "gray19" "gray20" "gray21" ## [175] "gray22" "gray23" "gray24" ## [178] "gray25" "gray26" "gray27" ## [181] "gray28" "gray29" "gray30" ## [184] "gray31" "gray32" "gray33" ## [187] "gray34" "gray32" "gray36" ## [190] "gray37" "gray38" "gray39" ## [191] "gray46" "gray41" "gray45" ## [199] "gray46" "gray47" "gray48" ## [202] "gray49" "gray50" "gray51" ## [208] "gray55" "gray56" "gray56" "gray57" ## [211] "gray64" "gray62" "gray66" ## [212] "gray61" "gray62" "gray69" ## [223] "gray70" "gray68" "gray72" ## [226] "gray73" "gray74" "gray75"	##	[142]	"gold"	"gold1"	"gold2"
## [151] "goldenrod4" "gray" "gray0" ## [154] "gray1" "gray2" "gray3" ## [157] "gray4" "gray5" "gray6" ## [160] "gray7" "gray8" "gray9" ## [163] "gray10" "gray11" "gray15" ## [166] "gray13" "gray14" "gray15" ## [169] "gray16" "gray17" "gray18" ## [172] "gray19" "gray20" "gray21" ## [178] "gray22" "gray23" "gray24" ## [178] "gray28" "gray29" "gray27" ## [184] "gray31" "gray29" "gray30" ## [184] "gray31" "gray32" "gray38" ## [190] "gray37" "gray38" "gray36" ## [190] "gray40" "gray41" "gray42" ## [191] "gray46" "gray47" "gray48" ## [202] "gray49" "gray50" "gray50" "gray51" ## [208] "gray55" "gray56" "gray57" ## [211] "gray64" "gray69" "gray60" ## [211] "gray64" "gray69" "gray60" ## [223] "gray70" "gray68" "gray72" ## [226] "gray73" "gray68" "gray69" ## [223] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##	[145]	"gold3"	"gold4"	"goldenrod"
## [154] "gray1" "gray2" "gray3" ## [157] "gray4" "gray5" "gray6" ## [160] "gray7" "gray8" "gray9" ## [163] "gray10" "gray11" "gray15" ## [166] "gray13" "gray14" "gray15" ## [169] "gray16" "gray17" "gray18" ## [172] "gray19" "gray20" "gray21" ## [175] "gray22" "gray23" "gray24" ## [178] "gray25" "gray26" "gray27" ## [181] "gray28" "gray29" "gray30" ## [184] "gray31" "gray32" "gray33" ## [190] "gray37" "gray38" "gray39" ## [191] "gray40" "gray41" "gray42" ## [199] "gray46" "gray44" "gray45" ## [202] "gray52" "gray58" "gray56" "gray56" ## [201] "gray58" "gray56" "gray60" ## [211] "gray58" "gray60" "gray60" ## [212] "gray64" "gray62" "gray60" ## [223] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##	[148]	"goldenrod1"	"goldenrod2"	"goldenrod3"
## [157] "gray4" "gray5" "gray6" ## [160] "gray7" "gray8" "gray9" ## [163] "gray10" "gray11" "gray12" ## [166] "gray13" "gray14" "gray15" ## [169] "gray16" "gray17" "gray18" ## [172] "gray19" "gray20" "gray21" ## [178] "gray22" "gray23" "gray24" ## [181] "gray28" "gray29" "gray30" ## [184] "gray31" "gray32" "gray30" ## [187] "gray34" "gray35" "gray36" ## [190] "gray37" "gray38" "gray39" ## [191] "gray40" "gray41" "gray42" ## [199] "gray46" "gray44" "gray45" ## [202] "gray49" "gray50" "gray51" ## [208] "gray55" "gray66" "gray69" ## [211] "gray61" "gray61" "gray62" "gray69" ## [222] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##	[151]	"goldenrod4"	"gray"	"gray0"
## [160] "gray7" "gray8" "gray9" ## [163] "gray10" "gray11" "gray12" ## [166] "gray13" "gray14" "gray15" ## [169] "gray16" "gray17" "gray18" ## [172] "gray19" "gray20" "gray21" ## [175] "gray22" "gray23" "gray24" ## [181] "gray28" "gray29" "gray30" ## [184] "gray31" "gray32" "gray33" ## [187] "gray34" "gray35" "gray36" ## [190] "gray37" "gray38" "gray42" ## [196] "gray40" "gray41" "gray42" ## [199] "gray46" "gray47" "gray48" ## [202] "gray49" "gray50" "gray51" ## [208] "gray55" "gray56" "gray60" ## [211] "gray61" "gray62" "gray60" ## [223] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##	[154]	"gray1"	"gray2"	"gray3"
## [163] "gray10" "gray11" "gray12" ## [166] "gray13" "gray14" "gray15" ## [169] "gray16" "gray17" "gray18" ## [172] "gray19" "gray20" "gray21" ## [175] "gray22" "gray23" "gray24" ## [181] "gray28" "gray29" "gray30" ## [184] "gray31" "gray32" "gray33" ## [187] "gray34" "gray35" "gray36" ## [190] "gray37" "gray38" "gray39" ## [193] "gray40" "gray41" "gray42" ## [196] "gray43" "gray44" "gray45" ## [202] "gray49" "gray50" "gray51" ## [208] "gray55" "gray56" "gray56" ## [211] "gray61" "gray62" "gray60" ## [212] "gray61" "gray68" "gray69" ## [223] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##	[157]	"gray4"	"gray5"	"gray6"
## [166] "gray13" "gray14" "gray15" ## [169] "gray16" "gray17" "gray18" ## [172] "gray19" "gray20" "gray21" ## [175] "gray22" "gray23" "gray24" ## [178] "gray25" "gray26" "gray30" ## [181] "gray28" "gray29" "gray30" ## [184] "gray31" "gray32" "gray33" ## [187] "gray34" "gray35" "gray36" ## [190] "gray37" "gray38" "gray39" ## [193] "gray40" "gray41" "gray42" ## [196] "gray43" "gray44" "gray45" ## [199] "gray46" "gray47" "gray48" ## [202] "gray49" "gray50" "gray51" ## [208] "gray55" "gray56" "gray57" ## [211] "gray58" "gray60" "gray60" ## [214] "gray61" "gray62" "gray60" ## [217] "gray64" "gray68" "gray69" ## [223] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##	[160]	"gray7"	"gray8"	"gray9"
## [169] "gray16" "gray17" "gray18" ## [172] "gray19" "gray20" "gray21" ## [175] "gray22" "gray23" "gray24" ## [178] "gray25" "gray26" "gray27" ## [181] "gray28" "gray29" "gray30" ## [184] "gray31" "gray32" "gray33" ## [190] "gray37" "gray38" "gray36" ## [191] "gray40" "gray38" "gray42" ## [196] "gray43" "gray44" "gray45" ## [199] "gray46" "gray47" "gray48" ## [202] "gray49" "gray50" "gray51" ## [208] "gray55" "gray56" "gray57" ## [211] "gray64" "gray62" "gray63" ## [220] "gray67" "gray68" "gray69" ## [223] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##	[163]	"gray10"	"gray11"	"gray12"
## [172] "gray19" "gray20" "gray21" ## [175] "gray22" "gray23" "gray24" ## [178] "gray25" "gray26" "gray27" ## [181] "gray28" "gray29" "gray30" ## [184] "gray31" "gray35" "gray36" ## [190] "gray37" "gray38" "gray39" ## [191] "gray40" "gray41" "gray42" ## [196] "gray43" "gray44" "gray45" ## [202] "gray49" "gray47" "gray48" ## [205] "gray52" "gray53" "gray54" ## [211] "gray58" "gray56" "gray57" ## [211] "gray64" "gray62" "gray60" ## [217] "gray64" "gray68" "gray69" ## [223] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##	[166]	"gray13"	"gray14"	"gray15"
## [175] "gray22" "gray26" "gray27" ## [178] "gray25" "gray26" "gray27" ## [181] "gray28" "gray29" "gray30" ## [184] "gray31" "gray32" "gray33" ## [187] "gray34" "gray35" "gray36" ## [190] "gray37" "gray38" "gray39" ## [191] "gray40" "gray41" "gray42" ## [196] "gray43" "gray44" "gray45" ## [202] "gray49" "gray47" "gray48" ## [202] "gray52" "gray53" "gray54" ## [208] "gray55" "gray56" "gray57" ## [211] "gray58" "gray66" "gray60" ## [214] "gray61" "gray62" "gray66" ## [220] "gray67" "gray68" "gray69" ## [223] "gray70" "gray71" "gray75"	##	[169]	"gray16"	"gray17"	"gray18"
## [178] "gray25" "gray26" "gray27" ## [181] "gray28" "gray29" "gray30" ## [184] "gray31" "gray32" "gray33" ## [187] "gray34" "gray35" "gray36" ## [190] "gray37" "gray38" "gray39" ## [193] "gray40" "gray41" "gray42" ## [196] "gray43" "gray44" "gray45" ## [199] "gray46" "gray47" "gray48" ## [202] "gray49" "gray50" "gray51" ## [205] "gray52" "gray53" "gray54" ## [208] "gray55" "gray56" "gray57" ## [211] "gray58" "gray59" "gray60" ## [214] "gray61" "gray62" "gray66" ## [220] "gray64" "gray65" "gray66" ## [220] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##	[172]	"gray19"	"gray20"	"gray21"
## [181] "gray28" "gray29" "gray30" ## [184] "gray31" "gray32" "gray33" ## [187] "gray34" "gray35" "gray36" ## [190] "gray37" "gray38" "gray39" ## [193] "gray40" "gray41" "gray42" ## [196] "gray43" "gray44" "gray45" ## [202] "gray49" "gray50" "gray51" ## [205] "gray52" "gray53" "gray54" ## [208] "gray55" "gray56" "gray57" ## [211] "gray58" "gray59" "gray60" ## [214] "gray61" "gray62" "gray63" ## [220] "gray64" "gray65" "gray66" ## [220] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"			"gray22"	"gray23"	"gray24"
## [184] "gray31" "gray32" "gray33" ## [187] "gray34" "gray35" "gray36" ## [190] "gray37" "gray38" "gray39" ## [193] "gray40" "gray41" "gray42" ## [196] "gray43" "gray44" "gray45" ## [202] "gray49" "gray50" "gray51" ## [205] "gray52" "gray53" "gray54" ## [208] "gray55" "gray56" "gray57" ## [211] "gray58" "gray59" "gray60" ## [214] "gray61" "gray62" "gray63" ## [220] "gray67" "gray68" "gray69" ## [223] "gray70" "gray71" "gray75"	##	[178]	"gray25"	"gray26"	"gray27"
## [187] "gray34" "gray35" "gray36" ## [190] "gray37" "gray38" "gray39" ## [193] "gray40" "gray41" "gray42" ## [196] "gray43" "gray44" "gray45" ## [202] "gray49" "gray50" "gray51" ## [205] "gray52" "gray53" "gray54" ## [208] "gray55" "gray56" "gray57" ## [211] "gray58" "gray59" "gray60" ## [214] "gray61" "gray62" "gray63" ## [220] "gray64" "gray65" "gray66" ## [220] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##	[181]	"gray28"	"gray29"	"gray30"
## [190] "gray37" "gray38" "gray39" ## [193] "gray40" "gray41" "gray42" ## [196] "gray43" "gray44" "gray45" ## [199] "gray46" "gray47" "gray48" ## [202] "gray49" "gray50" "gray51" ## [208] "gray52" "gray53" "gray54" ## [208] "gray55" "gray56" "gray57" ## [211] "gray58" "gray59" "gray60" ## [214] "gray61" "gray62" "gray63" ## [217] "gray64" "gray65" "gray66" ## [220] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##	[184]	"gray31"	"gray32"	"gray33"
## [193] "gray40" "gray41" "gray42" ## [196] "gray43" "gray44" "gray45" ## [199] "gray46" "gray47" "gray48" ## [202] "gray49" "gray50" "gray51" ## [208] "gray55" "gray56" "gray57" ## [211] "gray58" "gray59" "gray60" ## [214] "gray61" "gray62" "gray63" ## [217] "gray64" "gray65" "gray66" ## [220] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##	[187]	"gray34"	"gray35"	"gray36"
## [196] "gray43" "gray44" "gray45" ## [199] "gray46" "gray47" "gray48" ## [202] "gray49" "gray50" "gray51" ## [205] "gray52" "gray53" "gray54" ## [208] "gray55" "gray56" "gray57" ## [211] "gray58" "gray59" "gray60" ## [214] "gray61" "gray62" "gray63" ## [217] "gray64" "gray65" "gray66" ## [220] "gray67" "gray68" "gray69" ## [223] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##	[190]	"gray37"	"gray38"	"gray39"
## [199] "gray46" "gray47" "gray48" ## [202] "gray49" "gray50" "gray51" ## [205] "gray52" "gray53" "gray54" ## [208] "gray55" "gray56" "gray57" ## [211] "gray58" "gray59" "gray60" ## [214] "gray61" "gray62" "gray63" ## [217] "gray64" "gray65" "gray66" ## [220] "gray67" "gray68" "gray69" ## [223] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##	[193]	"gray40"	"gray41"	"gray42"
## [202] "gray49" "gray50" "gray51" ## [205] "gray52" "gray53" "gray54" ## [208] "gray55" "gray56" "gray57" ## [211] "gray58" "gray59" "gray60" ## [214] "gray61" "gray62" "gray63" ## [217] "gray64" "gray65" "gray66" ## [220] "gray67" "gray68" "gray69" ## [223] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##				
## [205] "gray52" "gray53" "gray54" ## [208] "gray55" "gray56" "gray57" ## [211] "gray58" "gray59" "gray60" ## [214] "gray61" "gray62" "gray63" ## [217] "gray64" "gray65" "gray66" ## [220] "gray67" "gray68" "gray69" ## [223] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##				
## [208] "gray55" "gray56" "gray57" ## [211] "gray58" "gray59" "gray60" ## [214] "gray61" "gray62" "gray63" ## [217] "gray64" "gray65" "gray66" ## [220] "gray67" "gray68" "gray69" ## [223] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##				
## [211] "gray58" "gray59" "gray60" ## [214] "gray61" "gray62" "gray63" ## [217] "gray64" "gray65" "gray66" ## [220] "gray67" "gray68" "gray69" ## [223] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##				
## [214] "gray61" "gray62" "gray63" ## [217] "gray64" "gray65" "gray66" ## [220] "gray67" "gray68" "gray69" ## [223] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##	[208]			
## [217] "gray64" "gray65" "gray66" ## [220] "gray67" "gray68" "gray69" ## [223] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##	[211]			
## [220] "gray67" "gray68" "gray69" ## [223] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##		"gray61"		
## [223] "gray70" "gray71" "gray72" ## [226] "gray73" "gray74" "gray75"	##				
## [226] "gray73" "gray74" "gray75"					
## [229] "gray76" "gray77" "gray78"	##				
	##	[229]	"gray76"	"gray77"	"gray78"

```
gray81"
   [232] "gray79"
                                   "grav80"
   [235]
##
         "gray82"
                                   "gray83"
                                                             gray84"
         "gray85"
                                    "gray86"
   [238]
                                                             "gray87"
##
   [241]
          "gray88"
                                    gray89"
                                                             "gray90"
         "gray91"
##
   [244]
                                    gray92"
                                                             "gray93"
   [247]
                                   "gray95"
                                                             "gray96"
##
          "gray94"
                                    gray98"
   [250]
                                                             "gray99"
         "gray97"
   [253]
##
          "gray100"
                                    "green"
                                                             "green1"
                                                             "green4"
##
   [256]
          "green2"
                                    "green3"
   [259]
          "greenyellow"
                                                             "grey0"
##
                                    "grey"
   [262]
          "grey1"
                                    grey2"
                                                             "grey3"
   [265]
          "grey4"
                                    grey5"
                                                             "grey6"
##
##
   [268]
         "grey7"
                                    grey8"
                                                             grey9"
                                    grey11"
##
   [271]
          "grey10"
                                                             grey12"
          "grey13"
   [274]
                                    "grey14"
                                                             grey15"
##
##
   [277]
          "grey16"
                                    grey17"
                                                             "grey18"
   [280]
##
          "grey19"
                                   "grey20"
                                                             grey21"
         "grey22"
   [283]
                                    "grev23"
                                                             "grev24"
   [286]
                                                             "grey27"
##
          "grey25"
                                    "grey26"
##
   [289]
          "grey28"
                                    "grey29"
                                                             "grey30"
##
   [292]
          "grey31"
                                   "grey32"
                                                             "grey33"
   [295]
         "grey34"
                                    "grey35"
                                                             "grey36"
##
   [298]
          "grey37"
                                    grey38"
                                                             "grey39"
##
          "grey40"
   [301]
                                    "grey41"
##
                                                             "grey42"
   [304]
         "grey43"
##
                                   "grey44"
                                                             "grey45"
   [307]
          "grey46"
                                    "grey47"
                                                             "grey48"
##
   [310]
         "grey49"
                                    grey50"
                                                             grey51"
   [313]
                                    grey53"
##
         "grey52"
                                                             "grey54"
                                                             "grey57"
##
   [316]
                                    "grey56"
         "grey55"
##
   [319]
          "grey58"
                                    grey59"
                                                             "grey60"
##
   [322]
          "grey61"
                                    "grey62"
                                                             "grey63"
##
   [325]
          "grey64"
                                   "grey65"
                                                             "grey66"
   [328]
          "grey67"
                                    grey68"
                                                             "grey69"
   [331]
                                                             "grey72"
##
          "grey70"
                                    grey71"
##
   [334]
          "grey73"
                                    "grev74"
                                                             "grey75"
                                   "grey77"
##
   [337]
          "grey76"
                                                             "grey78"
   [340]
          "grey79"
                                    grey80"
                                                             "grey81"
##
   [343]
          "grey82"
                                    grey83"
                                                             "grey84"
          "grey85"
                                                             grey87"
##
   [346]
                                    "grey86"
##
   [349]
          "grey88"
                                   "grey89"
                                                             "grey90"
   [352]
          "grey91"
                                    "grey92"
                                                             "grey93"
##
   [355]
          "grey94"
                                    "grey95"
                                                             "grey96"
   [358]
                                    "grey98"
                                                             "grey99"
##
          "grey97"
         "grey100"
                                   "honeydew"
##
   [361]
                                                             "honeydew1"
          "honeydew2"
                                    "honeydew3"
   [364]
                                                             "honeydew4"
          "hotpink"
##
   [367]
                                    "hotpink1"
                                                             "hotpink2"
                                                             "indianred"
##
   [370]
         "hotpink3"
                                   "hotpink4"
   [373]
         "indianred1"
                                                             "indianred3"
##
                                   "indianred2"
   [376] "indianred4"
                                    "ivory"
                                                             "ivory1"
                                    "ivory3"
                                                             "ivory4"
##
   [379]
         "ivory2"
##
   [382]
         "khaki"
                                    "khaki1"
                                                             "khaki2"
                                                             "lavender"
         "khaki3"
                                   "khaki4"
##
   [385]
##
   [388] "lavenderblush"
                                    "lavenderblush1"
                                                             "lavenderblush2"
                                   "lavenderblush4"
## [391] "lavenderblush3"
                                                             "lawngreen"
```

```
## [394] "lemonchiffon"
                                  "lemonchiffon1"
                                                           "lemonchiffon2"
   [397] "lemonchiffon3"
                                  "lemonchiffon4"
                                                           "lightblue"
  [400] "lightblue1"
                                  "lightblue2"
                                                           "lightblue3"
  [403] "lightblue4"
                                  "lightcoral"
                                                           "lightcyan"
##
   [406] "lightcyan1"
                                  "lightcyan2"
                                                           "lightcyan3"
## [409] "lightcyan4"
                                  "lightgoldenrod"
                                                           "lightgoldenrod1"
  [412] "lightgoldenrod2"
                                  "lightgoldenrod3"
                                                           "lightgoldenrod4"
## [415] "lightgoldenrodyellow"
                                  "lightgray"
                                                           "lightgreen"
   [418] "lightgrey"
                                  "lightpink"
                                                           "lightpink1"
  [421] "lightpink2"
                                  "lightpink3"
                                                           "lightpink4"
## [424] "lightsalmon"
                                  "lightsalmon1"
                                                           "lightsalmon2"
## [427] "lightsalmon3"
                                  "lightsalmon4"
                                                           "lightseagreen"
## [430] "lightskyblue"
                                  "lightskyblue1"
                                                           "lightskyblue2"
## [433] "lightskyblue3"
                                                           "lightslateblue"
                                  "lightskyblue4"
## [436] "lightslategray"
                                  "lightslategrey"
                                                           "lightsteelblue"
   [439] "lightsteelblue1"
                                  "lightsteelblue2"
                                                           "lightsteelblue3"
  [442] "lightsteelblue4"
                                  "lightyellow"
                                                           "lightyellow1"
  [445] "lightyellow2"
                                  "lightyellow3"
                                                           "lightvellow4"
  [448] "limegreen"
                                  "linen"
                                                           "magenta"
## [451] "magenta1"
                                  "magenta2"
                                                           "magenta3"
## [454] "magenta4"
                                  "maroon"
                                                           "maroon1"
## [457]
         "maroon2"
                                  "maroon3"
                                                           "maroon4"
                                  "mediumblue"
## [460] "mediumaquamarine"
                                                           "mediumorchid"
## [463]
         "mediumorchid1"
                                  "mediumorchid2"
                                                           "mediumorchid3"
## [466] "mediumorchid4"
                                  "mediumpurple"
                                                           "mediumpurple1"
## [469] "mediumpurple2"
                                  "mediumpurple3"
                                                           "mediumpurple4"
## [472]
         "mediumseagreen"
                                  "mediumslateblue"
                                                           "mediumspringgreen"
## [475] "mediumturquoise"
                                  "mediumvioletred"
                                                           "midnightblue"
                                  "mistyrose"
## [478] "mintcream"
                                                           "mistyrose1"
## [481] "mistyrose2"
                                                           "mistyrose4"
                                  "mistyrose3"
## [484]
         "moccasin"
                                  "navajowhite"
                                                           "navajowhite1"
   [487] "navajowhite2"
                                  "navajowhite3"
                                                           "navajowhite4"
  [490] "navy"
                                  "navyblue"
                                                           "oldlace"
                                                           "olivedrab2"
## [493] "olivedrab"
                                  "olivedrab1"
   [496] "olivedrab3"
                                  "olivedrab4"
                                                           "orange"
## [499] "orange1"
                                  "orange2"
                                                           "orange3"
## [502] "orange4"
                                  "orangered"
                                                           "orangered1"
## [505] "orangered2"
                                  "orangered3"
                                                           "orangered4"
## [508] "orchid"
                                  "orchid1"
                                                           "orchid2"
## [511] "orchid3"
                                  "orchid4"
                                                           "palegoldenrod"
## [514] "palegreen"
                                  "palegreen1"
                                                           "palegreen2"
## [517]
         "palegreen3"
                                  "palegreen4"
                                                           "paleturquoise"
  [520] "paleturquoise1"
                                  "paleturquoise2"
                                                           "paleturquoise3"
## [523]
         "paleturquoise4"
                                  "palevioletred"
                                                           "palevioletred1"
## [526] "palevioletred2"
                                  "palevioletred3"
                                                           "palevioletred4"
## [529]
         "papayawhip"
                                  "peachpuff"
                                                           "peachpuff1"
##
   [532]
         "peachpuff2"
                                  "peachpuff3"
                                                           "peachpuff4"
  [535]
         "peru"
                                  "pink"
                                                           "pink1"
  [538] "pink2"
                                  "pink3"
                                                           "pink4"
                                                           "plum2"
   [541] "plum"
                                  "plum1"
   [544] "plum3"
##
                                  "plum4"
                                                           "powderblue"
## [547] "purple"
                                  "purple1"
                                                           "purple2"
## [550] "purple3"
                                  "purple4"
                                                           "red"
## [553] "red1"
                                  "red2"
                                                           "red3"
```

```
## [556] "red4"
                                  "rosybrown"
                                                          "rosybrown1"
## [559] "rosybrown2"
                                  "rosybrown3"
                                                          "rosybrown4"
## [562] "royalblue"
                                  "royalblue1"
                                                          "royalblue2"
## [565] "royalblue3"
                                                          "saddlebrown"
                                  "royalblue4"
## [568] "salmon"
                                  "salmon1"
                                                          "salmon2"
## [571] "salmon3"
                                  "salmon4"
                                                          "sandybrown"
## [574] "seagreen"
                                  "seagreen1"
                                                          "seagreen2"
## [577] "seagreen3"
                                                          "seashell"
                                  "seagreen4"
## [580] "seashell1"
                                  "seashell2"
                                                          "seashell3"
## [583] "seashell4"
                                  "sienna"
                                                          "sienna1"
## [586] "sienna2"
                                  "sienna3"
                                                          "sienna4"
## [589] "skyblue"
                                  "skyblue1"
                                                          "skyblue2"
## [592] "skyblue3"
                                  "skyblue4"
                                                          "slateblue"
## [595] "slateblue1"
                                  "slateblue2"
                                                          "slateblue3"
## [598] "slateblue4"
                                  "slategray"
                                                          "slategray1"
## [601] "slategray2"
                                  "slategray3"
                                                          "slategray4"
## [604] "slategrey"
                                  "snow"
                                                          "snow1"
## [607] "snow2"
                                                          "snow4"
                                  "snow3"
## [610] "springgreen"
                                  "springgreen1"
                                                          "springgreen2"
                                                          "steelblue"
## [613] "springgreen3"
                                  "springgreen4"
## [616] "steelblue1"
                                  "steelblue2"
                                                          "steelblue3"
## [619] "steelblue4"
                                  "tan"
                                                          "tan1"
## [622] "tan2"
                                  "tan3"
                                                          "tan4"
## [625] "thistle"
                                  "thistle1"
                                                          "thistle2"
## [628] "thistle3"
                                  "thistle4"
                                                          "tomato"
## [631] "tomato1"
                                  "tomato2"
                                                          "tomato3"
## [634] "tomato4"
                                  "turquoise"
                                                          "turquoise1"
## [637] "turquoise2"
                                  "turquoise3"
                                                          "turquoise4"
## [640] "violet"
                                  "violetred"
                                                          "violetred1"
## [643] "violetred2"
                                  "violetred3"
                                                          "violetred4"
                                                          "wheat2"
## [646] "wheat"
                                  "wheat1"
## [649] "wheat3"
                                  "wheat4"
                                                          "whitesmoke"
                                                          "yellow2"
## [652] "yellow"
                                  "yellow1"
## [655] "yellow3"
                                                          "yellowgreen"
                                  "yellow4"
```

Notions basiques de programmation

Fonctions

[1] 110

```
ma_fonction(100, 10, 1000)
## [1] 1110
ma_fonction(z=10000, x=10, y=100)
## [1] 10110
Condition
# quelques opérateurs
2 < 3
## [1] TRUE
2 >= 2
## [1] TRUE
2 != 3
## [1] TRUE
4 == 4
## [1] TRUE
2 == 3 | 3 == 3
## [1] TRUE
2 == 3 & 3 == 3
## [1] FALSE
a <- 1
if (a == 1){
 print("a est bien égal à 1")
} else{
 print("a n'est pas égale à 1")
## [1] "a est bien égal à 1"
Attention: une seule chose doit être testée
v \leftarrow c(1, 3, 0)
v == 3
## [1] FALSE TRUE FALSE
if (v == 3){
 print("v est égal à 3")
```

} else{

```
print("v n'est pas égal à 3")
## Warning in if (v == 3) {: the condition has length > 1 and only the first
## element will be used
## [1] "v n'est pas égal à 3"
Boucles
for (i in 1:6){
  phrase <- paste("Voici le nombre", i)</pre>
  print(phrase)
## [1] "Voici le nombre 1"
## [1] "Voici le nombre 2"
## [1] "Voici le nombre 3"
## [1] "Voici le nombre 4"
## [1] "Voici le nombre 5"
## [1] "Voici le nombre 6"
prenoms <- c("pierre", "paul", "jacques", "louis")</pre>
for (i in 1:length(prenoms)){
  phrase <- paste("il ou elle s'appelle", prenoms[i])</pre>
  print(phrase)
## [1] "il ou elle s'appelle pierre"
## [1] "il ou elle s'appelle paul"
## [1] "il ou elle s'appelle jacques"
## [1] "il ou elle s'appelle louis"
for (p in prenoms){
  phrase <- paste("il ou elle s'appelle", p)</pre>
  print(phrase)
## [1] "il ou elle s'appelle pierre"
## [1] "il ou elle s'appelle paul"
## [1] "il ou elle s'appelle jacques"
## [1] "il ou elle s'appelle louis"
While (tant que)
a <- 1
while (a < 4){
```

print(paste("a est égal à", a))

[1] "a est égal à 1" ## [1] "a est égal à 2"

```
## [1] "a est égal à 3"
```

Packages

Chargement d'un package déjà installé

- CRAN: 11203 packages (août 2017) avec croissance exponentielle
- Bioconductor: 1381 "software" packages (août 2017)

```
# chargement d'un package déjà installé
library(survival)
# rend disponible des fonctions spécifiques aux modèles de survie, par exemple:
?coxph
```

Installation d'un package disponible sur le CRAN

```
# Installation d'un package disponible sur le CRAN
install.packages("packHV")
library(packHV)
?desc
```

installation d'un package disponible sur BioConductor

Note: la première installation d'un package BioConductor peut prendre du temps car il faut installer une série de packages de base.

```
# installation d'un package disponible sur Bioconductor
source("https://bioconductor.org/biocLite.R")
biocLite("rfPred")
# répondre "n" si R propose d'updater des packages
library(rfPred)
?rfPred_scores
```

Modélisation statistique

Modèle linéaire simple

```
# modèle linéaire simple
fit <- lm(formula=poids ~ taille, data=d)
fit

##
## Call:
## lm(formula = poids ~ taille, data = d)
##
## Coefficients:
## (Intercept) taille
## -75.7931 0.8276</pre>
```

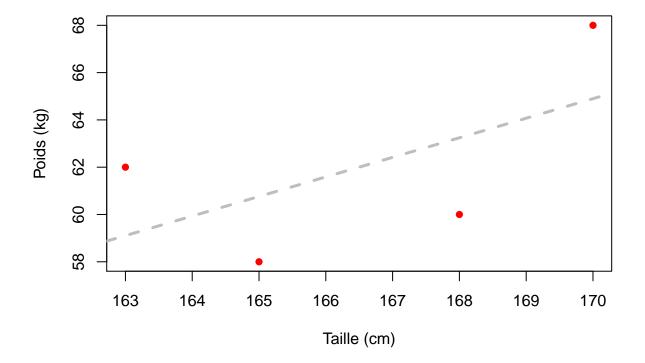
summary(fit)

```
##
## Call:
## lm(formula = poids ~ taille, data = d)
##
## Residuals:
##
               2
                      3
        1
## -2.759 -3.241 2.897 3.103
##
## Coefficients:
##
               Estimate Std. Error t value Pr(>|t|)
                                    -0.577
## (Intercept) -75.7931
                          131.4434
                                              0.622
## taille
                 0.8276
                            0.7893
                                     1.048
                                              0.404
##
## Residual standard error: 4.251 on 2 degrees of freedom
## Multiple R-squared: 0.3547, Adjusted R-squared:
## F-statistic: 1.099 on 1 and 2 DF, p-value: 0.4044
```

Interprétation graphique

```
# interprétation graphique
plot(formula=poids ~ taille, data=d, pch=16, col="red",
    main="Poids vs taille de 4 individus", xlab="Taille (cm)", ylab="Poids (kg)")
abline(a=-75.7931, b=0.8276, lty=2, lwd=3, col="grey")
```

Poids vs taille de 4 individus



Et plein d'autres choses

- $\bullet\,$ analyses exploratoires: ACP, clustering, etc
- tests statistiques
- génération automatique de rapports d'analyses en PDF/HTML via rmarkdown: mélange de texte, code et résultats
- applications web via R-Shiny (e.g. checkmyindex.pasteur.fr ou shaman.c3bi.pasteur.fr)