

# Stat 100a, Introduction to Probability. Rick Paik Schoenberg

## Outline for the day:

1. Addiction.
2. Syllabus, etc.
3. Wasicka/Gold/Binger example.
4. Meaning of probability.
5. Axioms of probability.
6. Hw1 terms.
7. Basic principle of counting.
8. Permutations and combinations.
9. *R*. ♠ ♣ ♥ ♦

## 2. Syllabus, etc.

For this week:

- (i) Learn the rules of Texas Hold'em.  
(see <http://www.fulltiltpoker.net> for example)
- (ii) Read addiction handout, addiction.pdf, on the course website,  
<http://www.stat.ucla.edu/~frederic/100a/F17> .
- (iii) Download R and try it out.  
( <http://cran.stat.ucla.edu> )
- (iv) Read ch. 1-3 of the textbook.

Note that the CCLE website for this course is not maintained. The course website is <http://www.stat.ucla.edu/~frederic/100a/F17> .

I do not give hw hints in office hours. Conceptual questions only.

Only one question is off limits, and it is “What did we do in class?”

If you have taken Stat 100a or Stat 35 before, please see me after class.

# Wasicka/Gold/Binger Example

Blinds: \$200,000-\$400,000 with \$50,000 antes.

## **Chip Counts:**

Jamie Gold                      \$60,000,000

Paul Wasicka                  \$18,000,000

Michael Binger                \$11,000,000

**Payouts:** 3rd place: \$4,123,310.      2nd place: \$6,102,499.      1st place: \$12,000,000.

Day 7, Hand 229.      Gold: 4s 3c.                      Binger: Ah 10h.                      Wasicka: 8s 7s.

An example of the type of questions we will be addressing in this class is on the next slide. Don't worry about all the details yet.

## Wasicka/Gold/Binger Example, Continued

Gold: 4♠ 3♣.    Binger: A♥ 10♥.    Wasicka: 8♠ 7♠  
Flop: 10♣ 6♠ 5♠.    (Turn: 7♣. River: Q♠)

---

Wasicka folded?!?

---

He had 8♠ 7♠ and the flop was 10♣ 6♠ 5♠ Worst case scenario?

## Wasicka/Gold/Binger Example, Continued

Gold: 4♠ 3♣.    Binger: A♥ 10♥.    Wasicka: 8♠ 7♠  
Flop: 10♣ 6♠ 5♠.    (Turn: 7♣. River: Q♠)

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Wasicka folded?!?

---

He had 8♠ 7♠ and the flop was 10♣ 6♠ 5♠ .

Suppose he were up against 9♠ 4♠ and 9♥ 9♦. How could Wasicka win?

88        (3: 8♣ 8♦, 8♣ 8♥, 8♦ 8♥)

77        (3)

44        (3)

[Let “X” = non-49, “Y” = A2378JQK, and “n” = non-♠.]

4n Xn    (3 x 32)

9♣ 4n    (3)

9♣ Yn    (24).    **Total: 132 out of 903 = 14.62%.**

## 4. Meaning of Probability.

Notation: “ $P(A) = 60\%$ ”.  $A$  is an *event*.

Not “ $P(60\%)$ ”.

Definition of probability:

Frequentist: If repeated independently under the same conditions millions and millions of times,  $A$  would happen 60% of the times.

Bayesian: Subjective feeling about how likely something seems.

$P(A \text{ or } B)$  means  $P(A \text{ or } B \text{ or both })$

*Mutually exclusive*:  $P(A \text{ and } B) = 0$ .

*Independent*:  $P(A \text{ given } B)$  [written “ $P(A|B)$ ”] =  $P(A)$ .

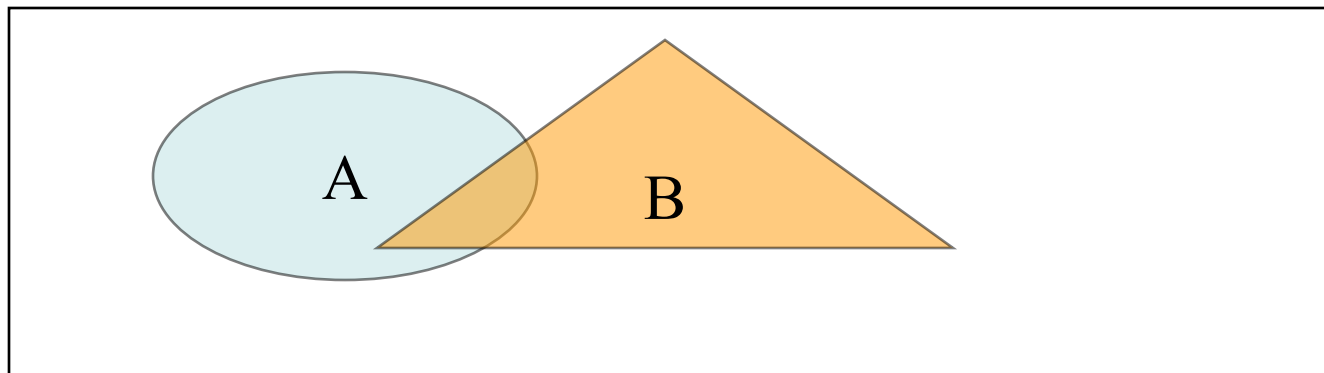
$P(A^c)$  means  $P(\text{not } A)$ .

## 5. Axioms (initial assumptions/rules) of probability:

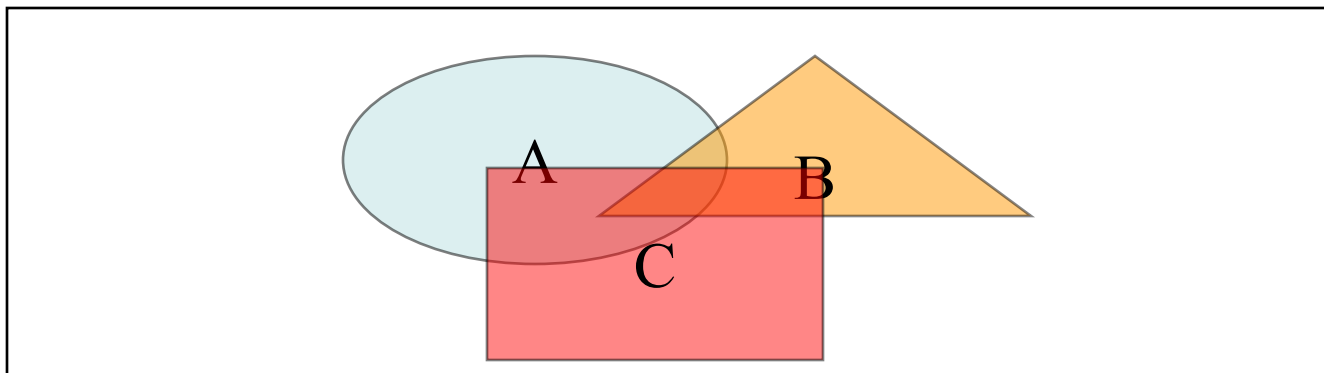
- 1)  $P(A) \geq 0$ .
- 2)  $P(A) + P(A^c) = 1$ .
- 3) If  $A_1, A_2, A_3, \dots$  are mutually exclusive, then  
 $P(A_1 \text{ or } A_2 \text{ or } A_3 \text{ or } \dots) = P(A_1) + P(A_2) + P(A_3) + \dots$

(#3 is sometimes called the *addition rule*)

Probability  $\Leftrightarrow$  Area. Measure theory, Venn diagrams



$$P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B).$$



Fact:  $P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B).$

$P(A \text{ or } B \text{ or } C) = P(A) + P(B) + P(C) - P(AB) - P(AC) - P(BC) + P(ABC).$

Fact: If  $A_1, A_2, \dots, A_n$  are equally likely & mutually exclusive,  
and if  $P(A_1 \text{ or } A_2 \text{ or } \dots \text{ or } A_n) = 1,$   
then  $P(A_k) = 1/n.$

[So, you can *count*:  $P(A_1 \text{ or } A_2 \text{ or } \dots \text{ or } A_k) = k/n.$ ]

Ex. You have 76, and the board is KQ54.  $P(\text{straight})?$

[52-2-4=46.]  $P(\text{straight}) = P(8 \text{ on river OR } 3 \text{ on river})$   
 $= P(8 \text{ on river}) + P(3 \text{ on river}) = 4/46 + 4/46.$

## 6. Hw1 terms.

**Assume you never fold.** I say this so one can't object "But I would never play 7♦ 5♦."

**flop a straight flush.** For example, you have 7♦ 5♦ and the flop is 4♦ 8♦ 6♦ .

**flopping 2 pairs.** For example, you have 7♦ 7♥ and the flop is 3♥ 3♠ J♥.

Or, you have 7♦ 3♥ and the flop is 7♥ 3♠ J♥.

**pocket pair.** When your two cards form a pair by themselves, like 7♦ 7♥.

**face cards.** K, Q, or J.

**the nuts.** Given the board, the best possible hand you could currently have in terms of the ranking order of poker hands, not in terms of probability of winning or improving in the future. For example, if the board is 7♥ 3♠ J♥ 8♦, then if you have 10♦ 9♦, then you have the nuts. If you have 10♥ 9♥, it would be slightly better in terms of probability of winning, but either way you have the nuts.

**the unbreakable nuts.** When you are guaranteed to win no matter what your opponent might have and no matter what board cards might come. In the above example where you have 10♥ 9♥ and the board is 7♥ 3♠ J♥ 8♦, you do not have the unbreakable nuts because you could lose for instance if the river is 9♠ and your opponent has Q♠ 10♦. However, if the board is 8♥ 7♥ 6♥ and you have 10♥ 9♥, then you have the unbreakable nuts.

**in terms of.** 3.2b is not easy. Assuming A and B are independent, you have to express the odds against (AB) using only  $O_A$  and  $O_B$ . You can't use any other variables. In part a you expressed it in terms of  $P(A)$  and  $P(B)$ , so just figure out how to convert  $P(A)$  into an expression of  $O_A$  .

## 7. Basic Principle of Counting.

If there are  $a_1$  distinct possible outcomes on trial #1, and for each of them, there are  $a_2$  distinct possible outcomes on trial #2, then there are  $a_1 \times a_2$  distinct possible *ordered* outcomes on both.

e.g. you get 1 card, opp. gets 1 card. # of distinct possibilities?  
 $52 \times 51$ . [ordered:  $(A\clubsuit, K\heartsuit) \neq (K\heartsuit, A\clubsuit)$  .]

In general, with  $j$  experiments, each with  $a_i$  possibilities, the # of distinct outcomes *where order matters* is  $a_1 \times a_2 \times \dots \times a_j$  .

## 8. Permutations and Combinations.

e.g. you get 1 card, opp. gets 1 card.

# of distinct possibilities?

$52 \times 51$ . [ordered: (A♣, K♥)  $\neq$  (K♥, A♣) .]

Each such outcome, where order matters, is called a *permutation*.

Number of permutations of the deck?  $52 \times 51 \times \dots \times 1 = 52!$

$$\sim 8.1 \times 10^{67}$$

A combination is a collection of outcomes, where order *doesn't* matter.

e.g. in hold'em, how many *distinct* 2-card hands are possible?

52 x 51 if order matters, but then you'd be double-counting each

[ since now (A♣, K♥) = (K♥, A♣) .]

So, the number of *distinct* hands where *order doesn't matter* is

52 x 51 / 2.

In general, with n distinct objects, the # of ways to choose k *different* ones, *where order doesn't matter*, is

$$\text{"n choose k"} = \text{choose}(n,k) = \frac{n!}{k! (n-k)!} .$$

9. **R.** To download and install *R*, go directly to [cran.stat.ucla.edu](http://cran.stat.ucla.edu), or as it says in the book at the bottom of p157, you can start at [www.r-project.org](http://www.r-project.org), in which case you click on “download *R*”, scroll down to UCLA, and click on [cran.stat.ucla.edu](http://cran.stat.ucla.edu). From there, click on “download *R* for ...”, and then get the latest version.

The screenshot shows the homepage of 'The R Project for Statistical Computing'. The browser window has a title bar 'The R Project for Statistical Computing' and a URL bar showing 'http://www.r-project.org/'. The page features the R logo on the left, a navigation menu with links like 'About R', 'What is R?', 'Contributors', 'Screenshots', 'What's new?', 'Download, Packages', 'CRAN', 'R Project Foundation', 'Members & Donors', 'Mailing Lists', 'Bug Tracking', 'Developer Page', 'Conferences', 'Search', 'Documentation', 'Manuals', 'FAQs', 'The R Journal', 'Wiki', 'Books', 'Certification', and 'Other'. The main content area displays several statistical plots: a PCA plot titled 'PCA 5 vars' with a biplot showing variables like Fertility, Catholic, Examination, Education, and Agriculture; a clustering dendrogram titled 'Clustering 4 groups'; a bar chart titled 'Groups' showing counts for four groups; and two normal distribution plots for 'Factor 1 [41%]' and 'Factor 3 [19%]'. A 'Getting Started:' section at the bottom provides instructions on downloading R and installing it, mentioning the CRAN mirror and frequently asked questions.

**The R Project for Statistical Computing**

PCA 5 vars  
prcomp(x = data, cor = cor)

Fertility  
Catholic  
Examination  
Education  
Agriculture  
(1-3) 60%

Clustering 4 groups

Groups  
28  
16  
1  
2

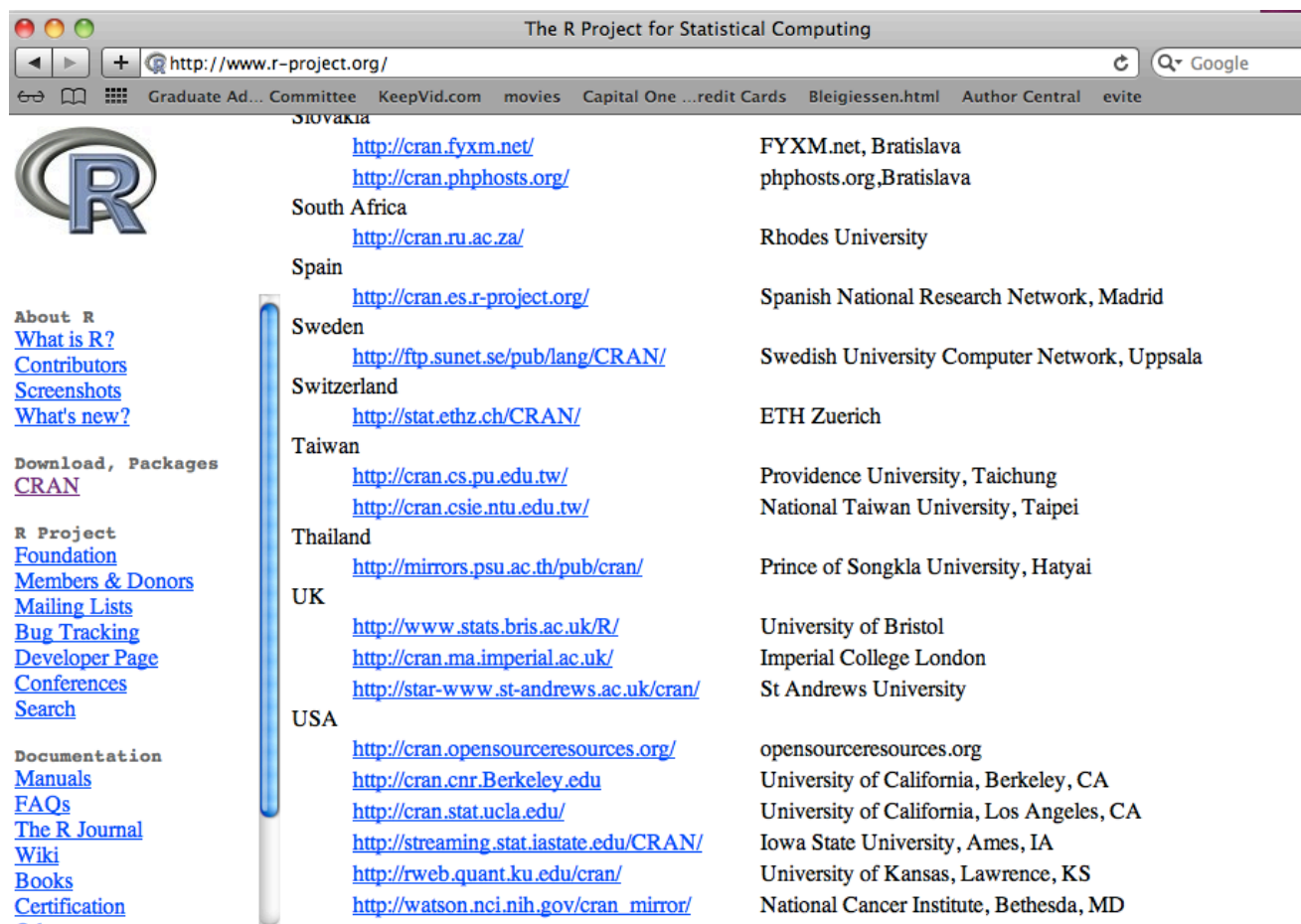
Factor 1 [41%]  
Factor 3 [19%]

Getting Started:

- R is a free software environment for statistical computing and graphics. It compiles and runs on a wide variety of UNIX platforms, Windows and MacOS. To **download R**, please choose your preferred [CRAN mirror](#).
- If you have questions about R like how to download and install the software, or what the license terms are, please read our [answers to frequently asked questions](#) before you send an email.

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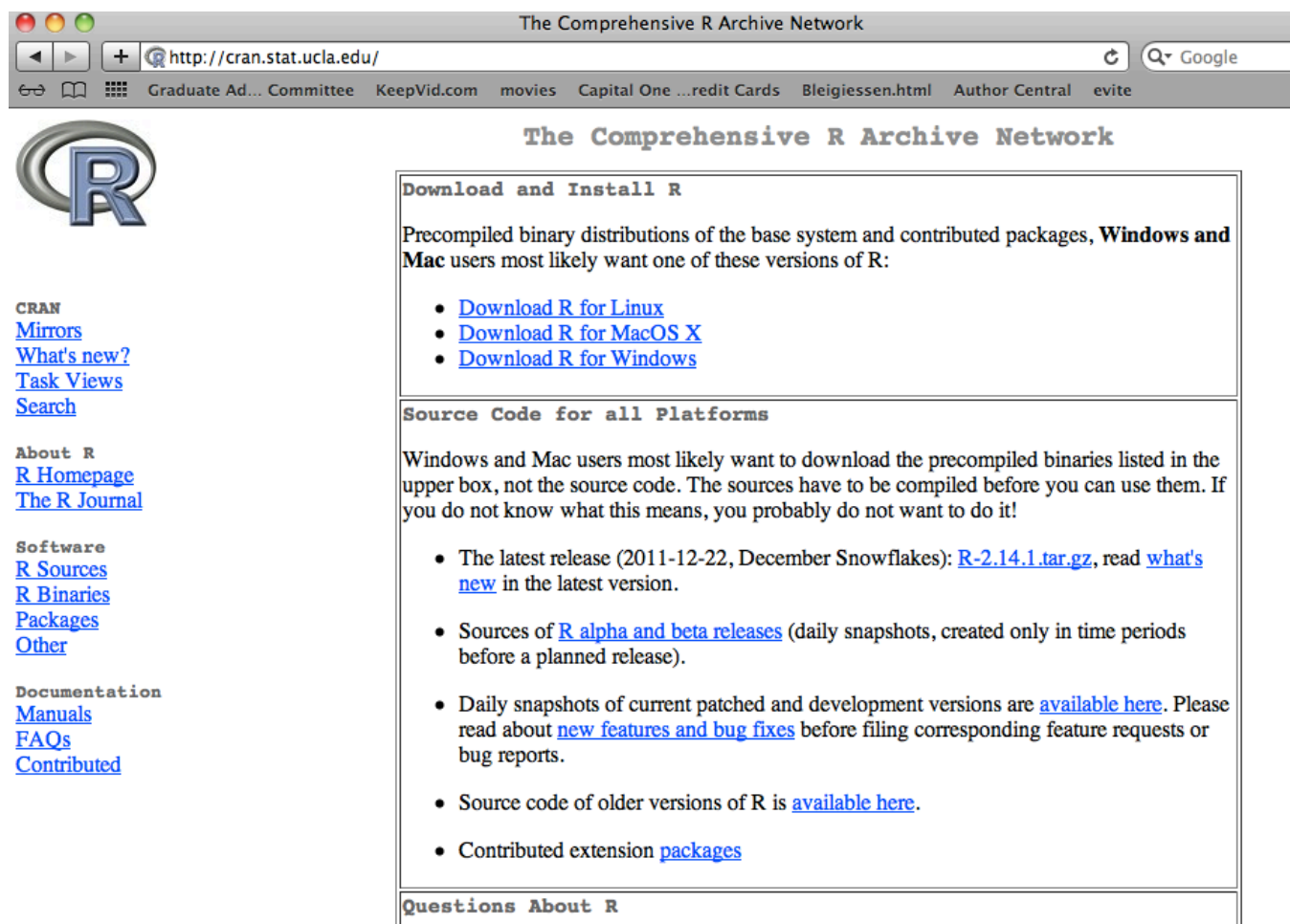
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| Country      | URL   | Institution                                  |
|--------------|---|--|
| Slovakia     | <a href="http://cran.fyxm.net/">http://cran.fyxm.net/</a>                                     | FYXM.net, Bratislava                         |
|              | <a href="http://cran.phphosts.org/">http://cran.phphosts.org/</a>                             | phphosts.org, Bratislava                     |
| South Africa | <a href="http://cran.ru.ac.za/">http://cran.ru.ac.za/</a>                                     | Rhodes University                            |
| Spain        | <a href="http://cran.es.r-project.org/">http://cran.es.r-project.org/</a>                     | Spanish National Research Network, Madrid    |
| Sweden       | <a href="http://ftp.sunet.se/pub/lang/CRAN/">http://ftp.sunet.se/pub/lang/CRAN/</a>           | Swedish University Computer Network, Uppsala |
| Switzerland  | <a href="http://stat.ethz.ch/CRAN/">http://stat.ethz.ch/CRAN/</a>                             | ETH Zuerich                                  |
| Taiwan       | <a href="http://cran.cs.pu.edu.tw/">http://cran.cs.pu.edu.tw/</a>                             | Providence University, Taichung              |
|              | <a href="http://cran.csie.ntu.edu.tw/">http://cran.csie.ntu.edu.tw/</a>                       | National Taiwan University, Taipei           |
| Thailand     | <a href="http://mirrors.psu.ac.th/pub/cran/">http://mirrors.psu.ac.th/pub/cran/</a>           | Prince of Songkla University, Hatyai         |
| UK           | <a href="http://www.stats.bris.ac.uk/R/">http://www.stats.bris.ac.uk/R/</a>                   | University of Bristol                        |
|              | <a href="http://cran.ma.imperial.ac.uk/">http://cran.ma.imperial.ac.uk/</a>                   | Imperial College London                      |
|              | <a href="http://star-www.st-andrews.ac.uk/cran/">http://star-www.st-andrews.ac.uk/cran/</a>   | St Andrews University                        |
| USA          | <a href="http://cran.opensourceresources.org/">http://cran.opensourceresources.org/</a>       | opensourceresources.org                      |
|              | <a href="http://cran.cnr.Berkeley.edu">http://cran.cnr.Berkeley.edu</a>                       | University of California, Berkeley, CA       |
|              | <a href="http://cran.stat.ucla.edu/">http://cran.stat.ucla.edu/</a>                           | University of California, Los Angeles, CA    |
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|              | <a href="http://rweb.quant.ku.edu/cran/">http://rweb.quant.ku.edu/cran/</a>                   | University of Kansas, Lawrence, KS           |
|              | <a href="http://watson.nci.nih.gov/cran_mirror/">http://watson.nci.nih.gov/cran_mirror/</a>   | National Cancer Institute, Bethesda, MD      |

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**The Comprehensive R Archive Network**

**Download and Install R**

Precompiled binary distributions of the base system and contributed packages, **Windows and Mac** users most likely want one of these versions of R:

- [Download R for Linux](#)
- [Download R for MacOS X](#)
- [Download R for Windows](#)

**Source Code for all Platforms**

Windows and Mac users most likely want to download the precompiled binaries listed in the upper box, not the source code. The sources have to be compiled before you can use them. If you do not know what this means, you probably do not want to do it!

- The latest release (2011-12-22, December Snowflakes): [R-2.14.1.tar.gz](#), read [what's new](#) in the latest version.
- Sources of [R alpha and beta releases](#) (daily snapshots, created only in time periods before a planned release).
- Daily snapshots of current patched and development versions are [available here](#). Please read about [new features and bug fixes](#) before filing corresponding feature requests or bug reports.
- Source code of older versions of R is [available here](#).
- Contributed extension [packages](#)

**Questions About R**

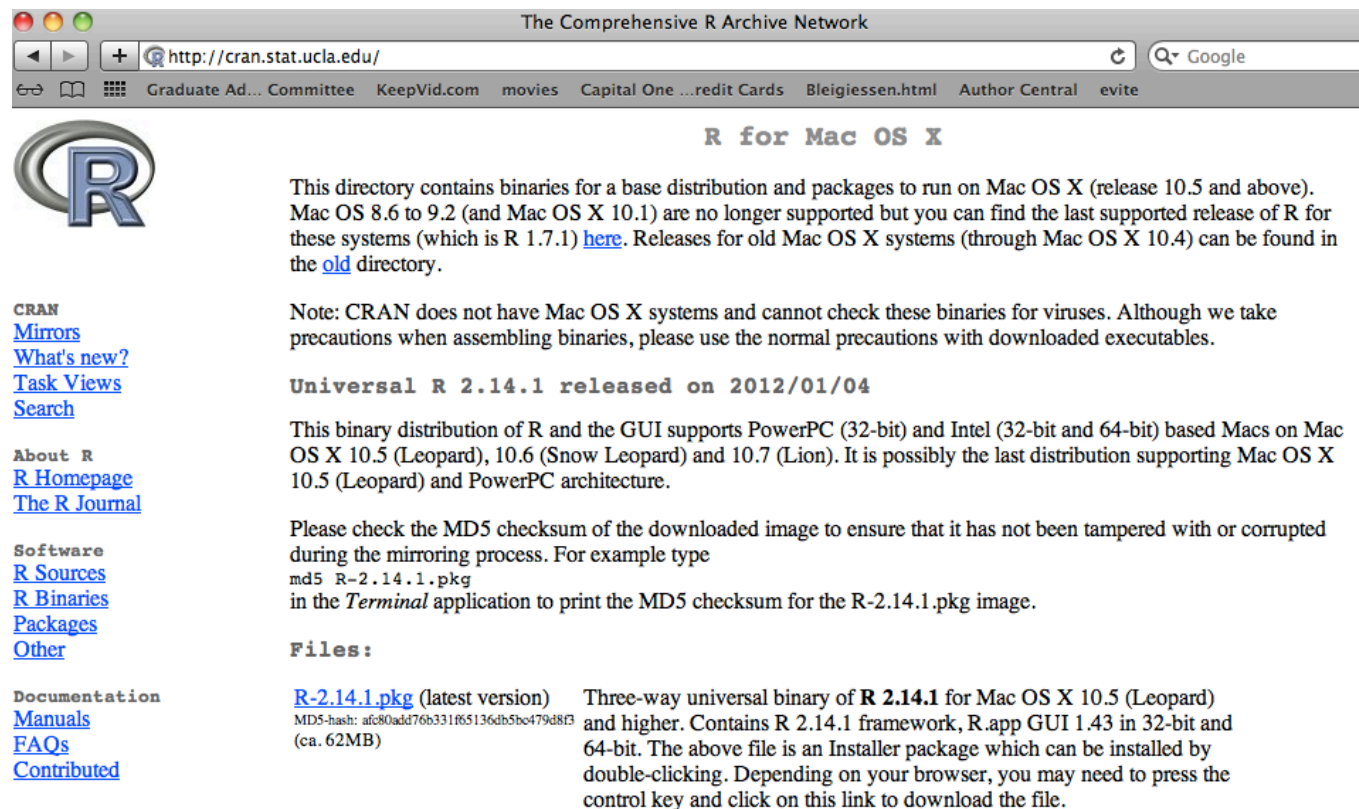
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The Comprehensive R Archive Network

<http://cran.stat.ucla.edu/>

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## R for Mac OS X

This directory contains binaries for a base distribution and packages to run on Mac OS X (release 10.5 and above). Mac OS 8.6 to 9.2 (and Mac OS X 10.1) are no longer supported but you can find the last supported release of R for these systems (which is R 1.7.1) [here](#). Releases for old Mac OS X systems (through Mac OS X 10.4) can be found in the [old](#) directory.

Note: CRAN does not have Mac OS X systems and cannot check these binaries for viruses. Although we take precautions when assembling binaries, please use the normal precautions with downloaded executables.

**Universal R 2.14.1 released on 2012/01/04**

This binary distribution of R and the GUI supports PowerPC (32-bit) and Intel (32-bit and 64-bit) based Macs on Mac OS X 10.5 (Leopard), 10.6 (Snow Leopard) and 10.7 (Lion). It is possibly the last distribution supporting Mac OS X 10.5 (Leopard) and PowerPC architecture.

Please check the MD5 checksum of the downloaded image to ensure that it has not been tampered with or corrupted during the mirroring process. For example type

```
md5 R-2.14.1.pkg
```

in the *Terminal* application to print the MD5 checksum for the R-2.14.1.pkg image.

**Files:**

|  |   |
|--|---|
| <a href="#">R-2.14.1.pkg</a> (latest version)<br>MD5-hash: afc80add76b33185136db5bc479d8f7<br>(ca. 62MB) | Three-way universal binary of <b>R 2.14.1</b> for Mac OS X 10.5 (Leopard) and higher. Contains R 2.14.1 framework, R.app GUI 1.43 in 32-bit and 64-bit. The above file is an Installer package which can be installed by double-clicking. Depending on your browser, you may need to press the control key and click on this link to download the file. |
|--|---|

This package **only** contains the R framework, 32-bit GUI (R.app) and 64-bit GUI (R64.app). **For Tcl/Tk libraries (needed if you want to use tcltk) and GNU Fortran (needed if you want to compile packages from sources that contain FORTRAN code) please see [the tools](#)**