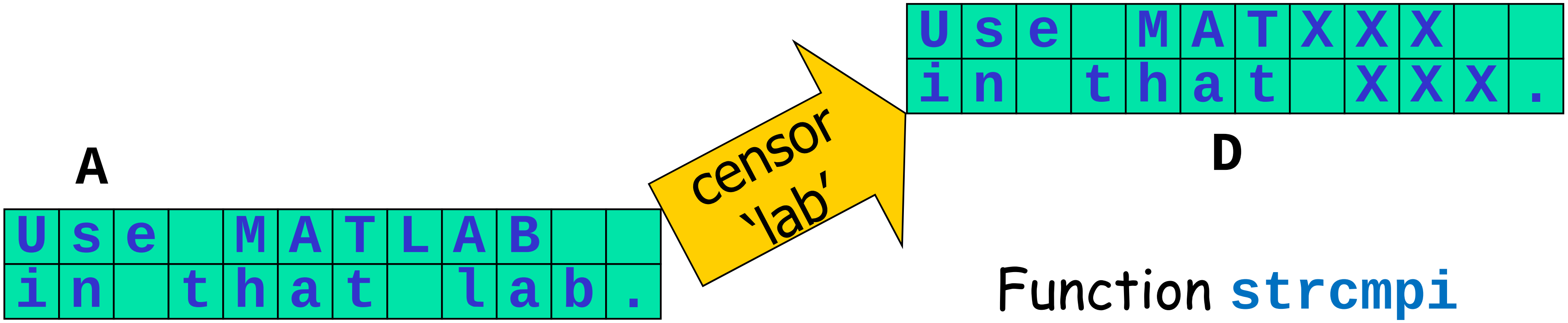
- Previous Lecture:
  - Characters and strings
- Today's Lecture:
  - More on characters and strings
  - Cell arrays
  - File input/output
- Announcements:
  - Discussion this week in computer lab
  - Project 4 due on Wednesday at 11pm

Example: censoring words

```
function D = censor(str, A)
% Replace all occurrences of string str in
% character matrix A with X’s, regardless of
% case.
% Assume str is never split across two lines.
% D is A with X’s replacing str.
```



A

U	s	e		M	A	T	L	A	B		
i	n		t	h	a	t		l	a	b	.

D

U	s	e		M	A	T	X	X	X		
i	n		t	h	a	t		X	X	X	.

Function **strcmpi** does case-insensitive string comparison

```
function D = censor(str, A)
% Replace all occurrences of string str in character matrix A,
% regardless of case, with X's.
% A is a matrix of characters.
% str is a string.  Assume that str is never split across two lines.
% D is A with X's replacing the censored string str.

D= A;
ns= length(str);
[nr,nc]= size(A);

% Build a string of X's of the right length




% Traverse the matrix to censor string str
```

```
function D = censor(str, A)
% Replace all occurrences of string str in character matrix A,
% regardless of case, with X's.
% A is a matrix of characters.
% str is a string.  Assume that str is never split across two lines.
% D is A with X's replacing the censored string str.

D= A;
ns= length(str);
[nr,nc]= size(A);

% Build a string of X's of the right length
Xs= char( zeros(1,ns));
for k= 1:ns
    Xs(k)= 'X';
end

% Traverse the matrix to censor string str
for r= 1:nr
    for c= 1:nc-ns+1
        if  strcmpi( str , A(r, c:c+ns-1) )==1
            D(r, c:c+ns-1)= Xs;
        end
    end
end
```

Xs	X	X	X

	1	2	3		…			8	9	10	11	12
A	U	s	e		M	A	T	L	A	B		
	i	n		t	h	a	t		l	a	b	.

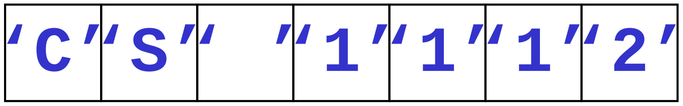
Returns an array of type **double**

Changes the type to **char**

Case insensitive comparison of strings

Array vs. Cell Array

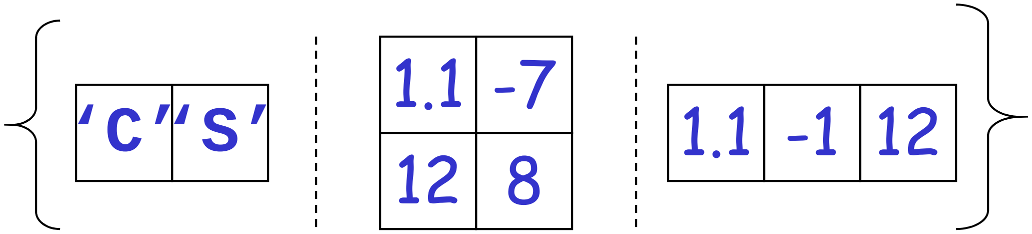
- Simple array



'C'	'S'	' '	'1'	'1'	'1'	'2'

  - Each component stores one scalar. E.g., one char, one double, or one uint8 value
  - All components have the same type

- Cell array



  - Each cell can store something “bigger” than one scalar, e.g., a vector, a matrix, a string (vector of chars)
  - The cells may store items of different types

1-d and 2-d examples …

Vectors and matrices store values of the same type in all components

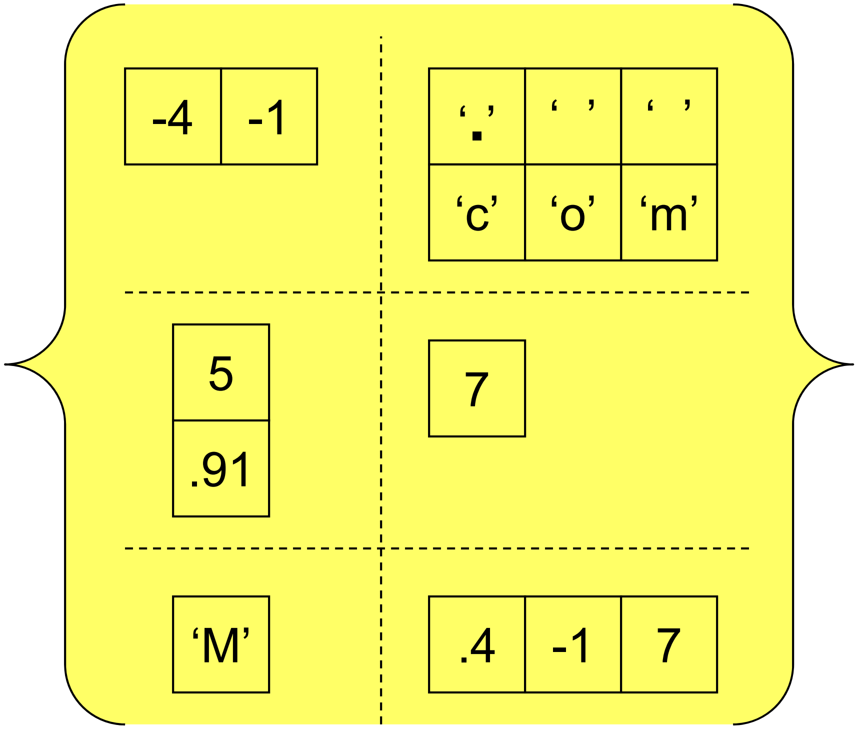
3.1
2
-1
9
1.1

5 x 1 matrix

‘c’	‘o’	‘m’	‘ ’	‘s’
‘1’	‘1’	‘1’	‘2’	‘ ’
‘M’	‘a’	‘t’	‘ ’	‘ ’
‘ ’	‘ ’	‘L’	‘A’	‘B’

4 x 5 matrix

Cell array: individual components may contain different types of data



-4 -1

‘.’ ‘ ’ ‘ ’
‘c’ ‘o’ ‘m’

5
.91

7

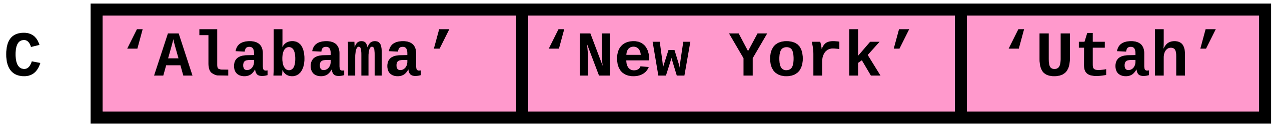
‘M’

.4 -1 7

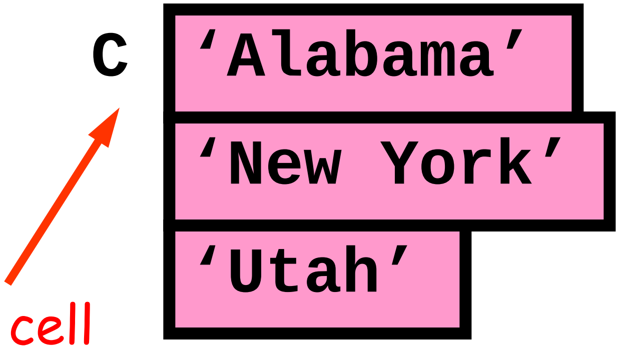
3 × 2 cell array

Cell Arrays of Strings

```
C= { ‘Alabama’,’New York’,’Utah’}
```


C ‘Alabama’ ‘New York’ ‘Utah’

```
C= { ‘Alabama’;’New York’;’Utah’}
```


C
‘Alabama’
‘New York’
‘Utah’

1-d cell array of strings

Contrast with
2-d array of characters

```
M= [‘Alabama ’; ...
    ‘New York’; ...
    ‘Utah    ’]
```

M

‘A’	‘l’	‘a’	‘b’	‘a’	‘m’	‘a’	‘ ‘
‘N’	‘e’	‘w’	‘ ‘	‘Y’	‘o’	‘r’	‘k’
‘U’	‘t’	‘a’	‘h’	‘ ‘	‘ ‘	‘ ‘	‘ ‘

Use braces { } for creating and addressing cell arrays

Matrix

- Create

```
m= [ 5, 4 ; …
     1, 2 ; …
     0, 8 ]
```

- Addressing

```
m(2,1)= pi
```

Cell Array

- Create

```
C= { ones(2,2), 4              ; …
          ‘abc’    , ones(3,1) ; …
            9      , ‘a cell’      }
```

- Addressing

```
C{2,1}= ‘ABC’
C{3,2}= pi
disp(C{3,2})
```

Creating cell arrays…

```
    C= {‘Oct’, 30, ones(3,2)};
```

is the same as

```
    C= cell(1,3); % not necessary
    C{1}= ‘Oct’;
    C{2}= 30;
    C{3}= ones(3,2);
```

You can assign the empty cell array: `D = {}`

Example: Represent a deck of cards with a cell array

```
D{1} = ‘A Hearts’;
D{2} = ‘2 Hearts’;
            :
D{13} = ‘K Hearts’;
D{14} = ‘A Clubs’;
            :
D{52} = ‘K Diamonds’;
```

But we don’t want to have to type all combinations of suits and ranks in creating the deck... How to proceed?

Make use of a suit array and a rank array …

```
suit = {‘Hearts’, ‘Clubs’, …
          ‘Spades’, ‘Diamonds’};
```

```
rank = {‘A’,‘2’,’3’,’4’,’5’,’6’,…
    ’7’,’8’,’9’,’10’,’J’,’Q’,’K’};
```

Then concatenate to get a card. E.g.,

```
str = [rank{3} ‘ ’ suit{2} ];
D{16} = str;
```

So **D{16}** stores **‘3 Clubs’**

To get all combinations, use nested loops

```
suit= {’Hearts’,’Clubs’,’Spades’,’Diamonds’};
rank= {’A’,’2’,’3’,’4’,’5’,’6’,’7’,’8’,’9’,...
       ’10’,’J’,’Q’,’K’};
i= 1;  % index of next card
for k= 1:4
   % Set up the cards in suit k
   for j= 1:13
      D{i}= [ rank{j} ' ' suit{k} ];
      i= i + 1;
   end
end
```

See function **CardDeck**

```
function D = CardDeck()
% D is 1-by-52 cell array of strings that define a card deck
```

```
suit= {’Hearts’,’Clubs’,’Spades’,’Diamonds’};
rank= {’A’,’2’,’3’,’4’,’5’,’6’,’7’,’8’,’9’,...
       ’10’,’J’,’Q’,’K’};
i= 1;  % index of next card
for k= 1:4
   % Set up the cards in suit k
   for j= 1:13
      D{i}= [ rank{j} ' ' suit{k} ];
      i= i + 1;
   end
end
```

Example: deal a 12-card deck

D: 🟥 🟫 🟦 🟩 🟥 🟫 🟦 🟩 🟥 🟫 🟦 🟩

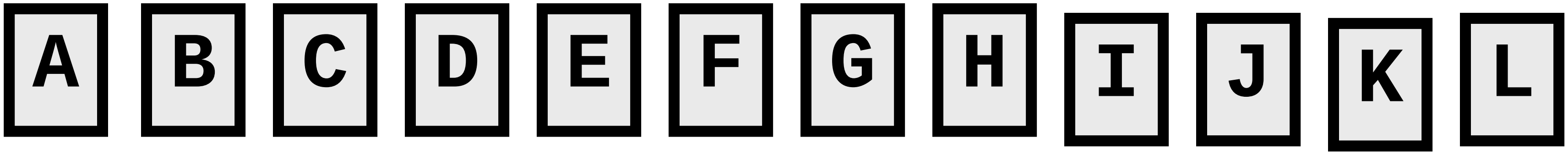
N:	🟥 🟥 🟥	1,5,9	4k-3
E:	🟫 🟫 🟫	2,6,10	4k-2
S:	🟦 🟦 🟦	3,7,11	4k-1
W:	🟩 🟩 🟩	4,8,12	4k

```
% Deal a 52-card deck
N = cell(1,13); E = cell(1,13);
S = cell(1,13); W = cell(1,13);

for k=1:13
   N{k} = D{4*k-3};
   E{k} = D{4*k-2};
   S{k} = D{4*k-1};
   W{k} = D{4*k};
end
```

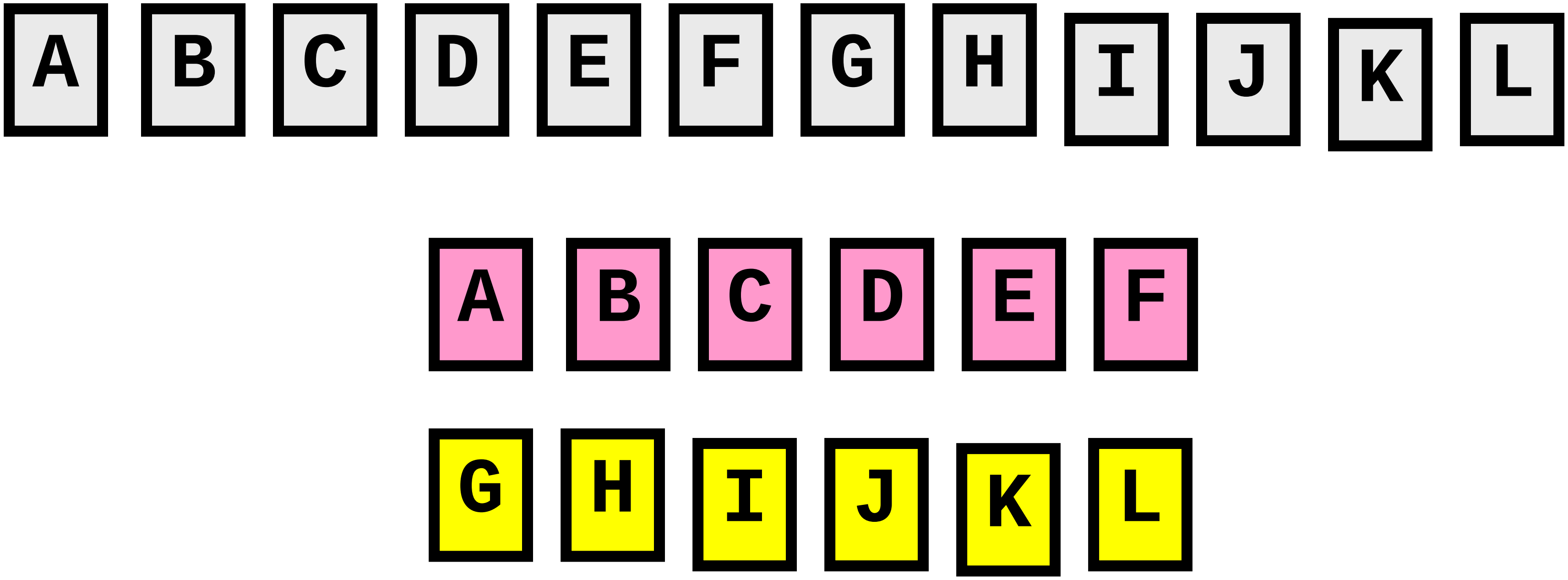
See function **`Deal`**

The "perfect shuffle" of a 12-card deck

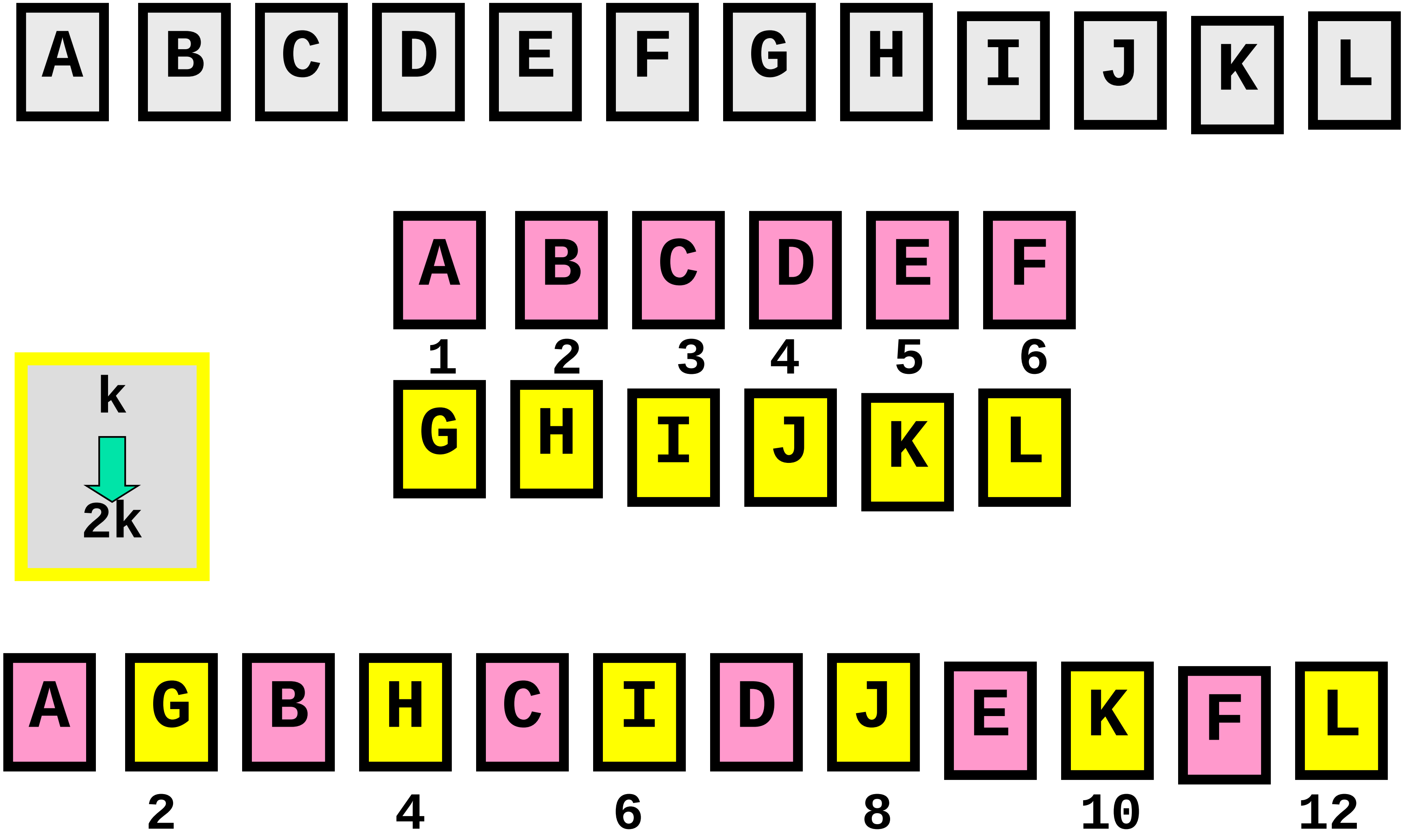


A B C D E F G H I J K L

Perfect Shuffle, Step 1: cut the deck



Perfect Shuffle, Step 2: Alternate



A B C D E F G H I J K L

A B C D E F

1 2 3 4 5 6

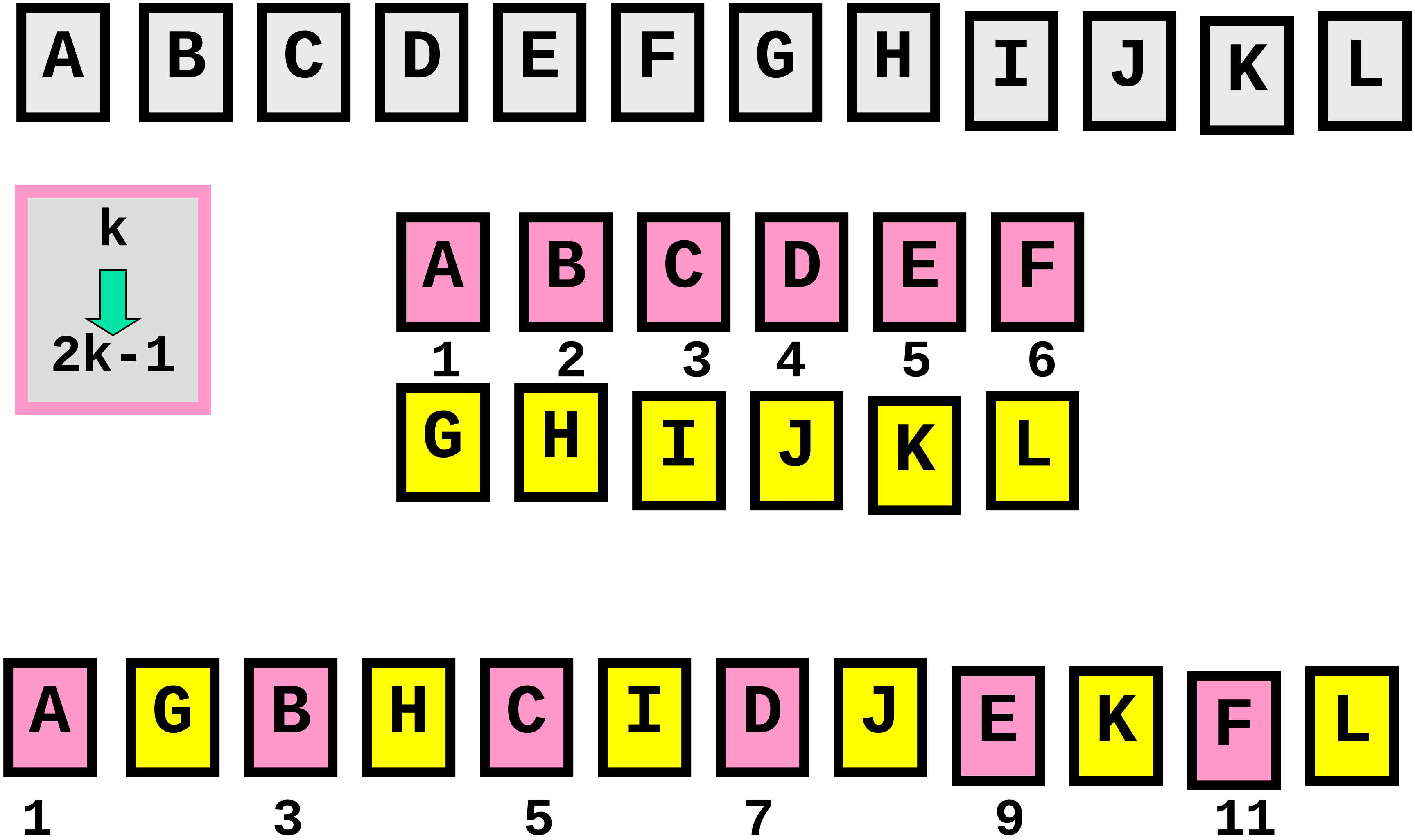
G H I J K L

k → 2k

A G B H C I D J E K F L

2 4 6 8 10 12

Perfect Shuffle, Step 2: Alternate

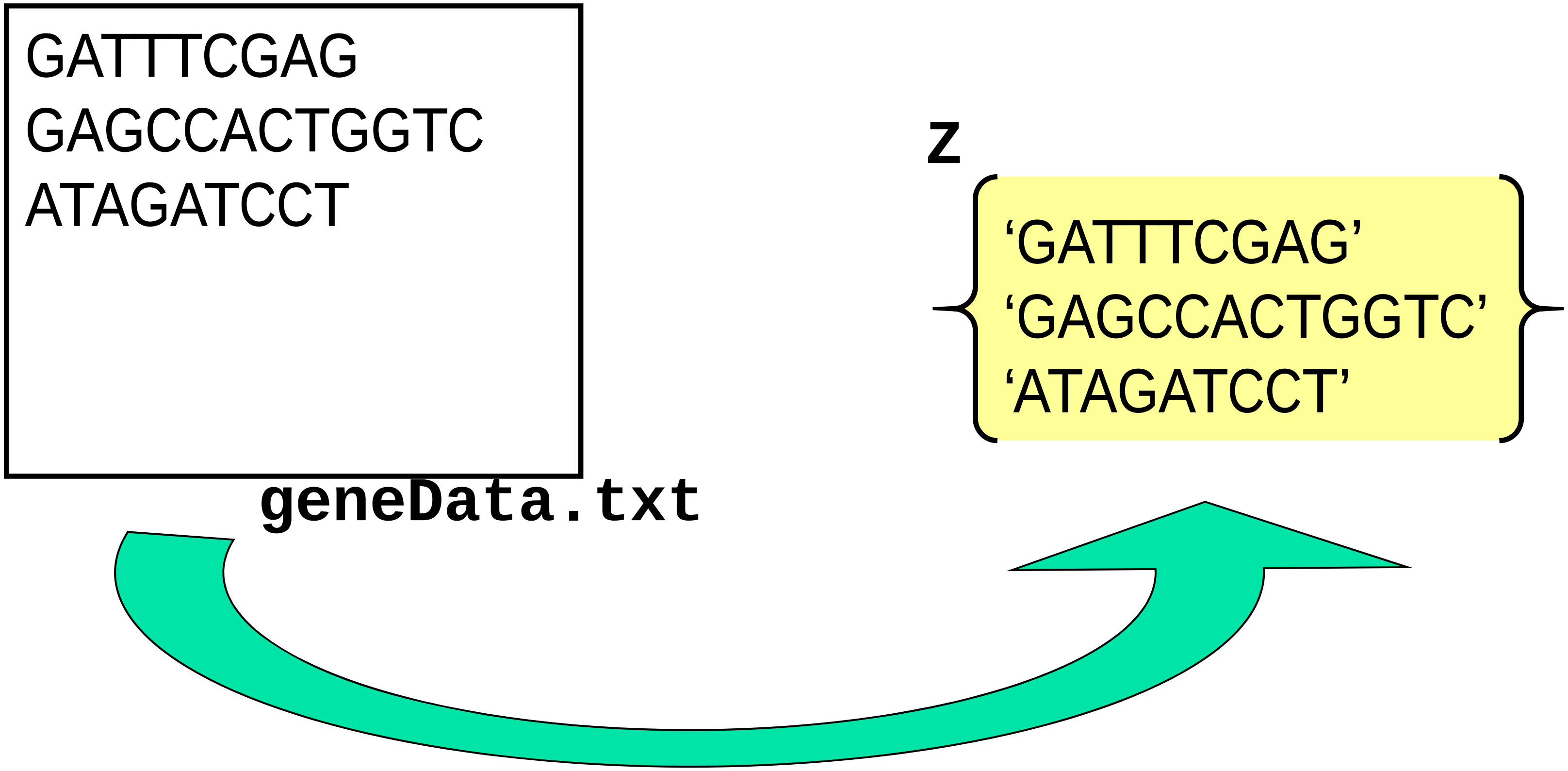


See function **Shuffle**

A 3-step process to read data from a file or write data to a file

1. (Create and) open a file
2. Read data from or write data to the file
3. Close the file

Working with data files: Read the data in a file line-by-line and store the results in a cell array



GATTTCGAG
GAGCCACTGGTC
ATAGATCCT

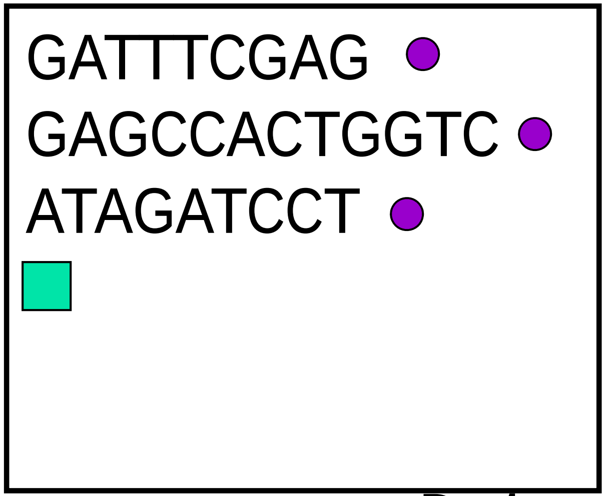
geneData.txt

z

'GATTTCGAG'
'GAGCCACTGGTC'
'ATAGATCCT'

How are lines separated?
How do we know when there are no more lines?

In a file there are hidden “markers”



GATTTCGAG ●
GAGCCACTGGTC ●
ATAGATCCT ●
🟩

`geneData.txt`

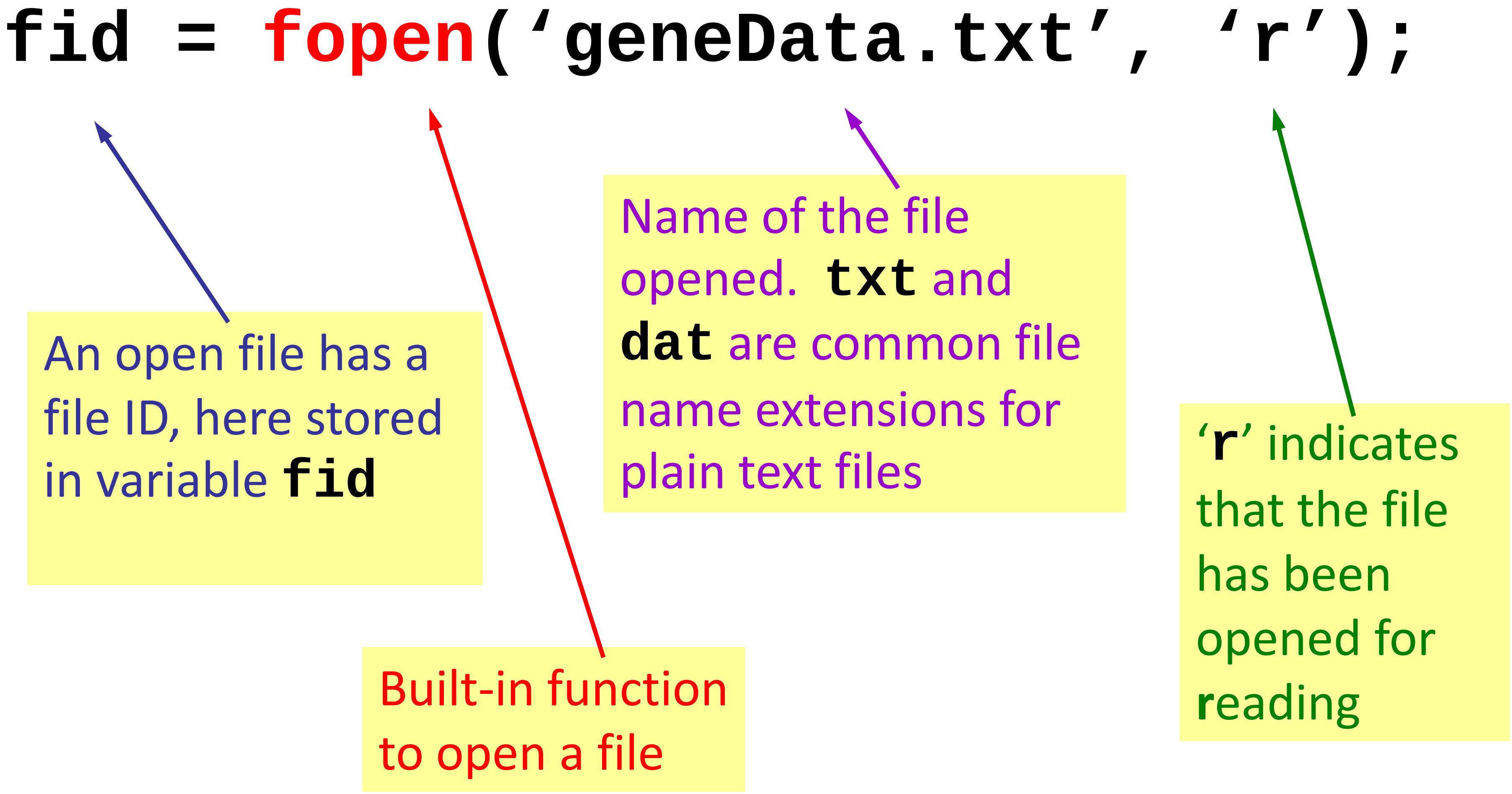
● Carriage return marks the end of a line

🟩 eof marks the end of a file

Read data from a file

1. Open a file
2. Read it line-by-line until eof
3. Close the file

1. Open the file



```
fid = fopen('geneData.txt', 'r');
```

An open file has a file ID, here stored in variable **`fid`**

Built-in function to open a file

Name of the file opened. **`txt`** and **`dat`** are common file name extensions for plain text files

'**`r`**' indicates that the file has been opened for reading

2. Read each line and store it in cell array

```
fid = fopen(‘geneData.txt’, ‘r’);

k= 0;
while ~feof(fid)
   k= k+1;
   Z{k}= fgetl(fid);
end
```

False until end-of-file is reached

Get the next line

3. Close the file

```
fid = fopen(‘geneData.txt’, ‘r’);


k= 0;
while ~feof(fid)
   k= k+1;
   Z{k}= fgetl(fid);
end

fclose(fid);
```