Creating Arrays from Python Lists

First, we can use `np.array` to create arrays from Python lists:

```
In[8]: # integer array:
       np.array([1, 4, 2, 5, 3])

Out[8]: array([1, 4, 2, 5, 3])
```

Remember that unlike Python lists, NumPy is constrained to arrays that all contain the same type. If types do not match, NumPy will upcast if possible (here, integers are upcast to floating point):

```
In[9]: np.array([3.14, 4, 2, 3])

Out[9]: array([ 3.14,  4.  ,  2.  ,  3.  ])
```

If we want to explicitly set the data type of the resulting array, we can use the `dtype` keyword:

```
In[10]: np.array([1, 2, 3, 4], dtype='float32')

Out[10]: array([ 1.,  2.,  3.,  4.], dtype=float32)
```

Finally, unlike Python lists, NumPy arrays can explicitly be multidimensional; here's one way of initializing a multidimensional array using a list of lists:

```
In[11]: # nested lists result in multidimensional arrays
        np.array([range(i, i + 3) for i in [2, 4, 6]])

Out[11]: array([[2, 3, 4],
                [4, 5, 6],
                [6, 7, 8]])
```

The inner lists are treated as rows of the resulting two-dimensional array.

Creating Arrays from Scratch

Especially for larger arrays, it is more efficient to create arrays from scratch using routines built into NumPy. Here are several examples:

```
In[12]: # Create a length-10 integer array filled with zeros
        np.zeros(10, dtype=int)

Out[12]: array([0, 0, 0, 0, 0, 0, 0, 0, 0, 0])

In[13]: # Create a 3x5 floating-point array filled with 1s
        np.ones((3, 5), dtype=float)

Out[13]: array([[ 1.,  1.,  1.,  1.,  1.],
                [ 1.,  1.,  1.,  1.,  1.],
                [ 1.,  1.,  1.,  1.,  1.]])

In[14]: # Create a 3x5 array filled with 3.14
        np.full((3, 5), 3.14)
```

```
Out[14]: array([[ 3.14,  3.14,  3.14,  3.14,  3.14],
                [ 3.14,  3.14,  3.14,  3.14,  3.14],
                [ 3.14,  3.14,  3.14,  3.14,  3.14]])

In[15]: # Create an array filled with a linear sequence
        # Starting at 0, ending at 20, stepping by 2
        # (this is similar to the built-in range() function)
        np.arange(0, 20, 2)

Out[15]: array([ 0,  2,  4,  6,  8, 10, 12, 14, 16, 18])

In[16]: # Create an array of five values evenly spaced between 0 and 1
        np.linspace(0, 1, 5)

Out[16]: array([ 0.  ,  0.25,  0.5 ,  0.75,  1.  ])

In[17]: # Create a 3x3 array of uniformly distributed
        # random values between 0 and 1
        np.random.random((3, 3))

Out[17]: array([[ 0.99844933,  0.52183819,  0.22421193],
                [ 0.08007488,  0.45429293,  0.20941444],
                [ 0.14360941,  0.96910973,  0.946117  ]])

In[18]: # Create a 3x3 array of normally distributed random values
        # with mean 0 and standard deviation 1
        np.random.normal(0, 1, (3, 3))

Out[18]: array([[ 1.51772646,  0.39614948, -0.10634696],
                [ 0.25671348,  0.00732722,  0.37783601],
                [ 0.68446945,  0.15926039, -0.70744073]])

In[19]: # Create a 3x3 array of random integers in the interval [0, 10)
        np.random.randint(0, 10, (3, 3))

Out[19]: array([[2, 3, 4],
                [5, 7, 8],
                [0, 5, 0]])

In[20]: # Create a 3x3 identity matrix
        np.eye(3)

Out[20]: array([[ 1.,  0.,  0.],
                [ 0.,  1.,  0.],
                [ 0.,  0.,  1.]])

In[21]: # Create an uninitialized array of three integers
        # The values will be whatever happens to already exist at that
        # memory location
        np.empty(3)

Out[21]: array([ 1.,  1.,  1.])
```

NumPy Standard Data Types

NumPy arrays contain values of a single type, so it is important to have detailed knowledge of those types and their limitations. Because NumPy is built in C, the types will be familiar to users of C, Fortran, and other related languages.

The standard NumPy data types are listed in Table 2-1. Note that when constructing an array, you can specify them using a string:

```
np.zeros(10, dtype='int16')
```

Or using the associated NumPy object:

```
np.zeros(10, dtype=np.int16)
```

Table 2-1. Standard NumPy data types

Data type	Description
`bool_`	Boolean (True or False) stored as a byte
`int_`	Default integer type (same as C `long`; normally either `int64` or `int32`)
`intc`	Identical to C `int` (normally `int32` or `int64`)
`intp`	Integer used for indexing (same as C `ssize_t`; normally either `int32` or `int64`)
`int8`	Byte (–128 to 127)
`int16`	Integer (–32768 to 32767)
`int32`	Integer (–2147483648 to 2147483647)
`int64`	Integer (–9223372036854775808 to 9223372036854775807)
`uint8`	Unsigned integer (0 to 255)
`uint16`	Unsigned integer (0 to 65535)
`uint32`	Unsigned integer (0 to 4294967295)
`uint64`	Unsigned integer (0 to 18446744073709551615)
`float_`	Shorthand for `float64`
`float16`	Half-precision float: sign bit, 5 bits exponent, 10 bits mantissa
`float32`	Single-precision float: sign bit, 8 bits exponent, 23 bits mantissa
`float64`	Double-precision float: sign bit, 11 bits exponent, 52 bits mantissa
`complex_`	Shorthand for `complex128`
`complex64`	Complex number, represented by two 32-bit floats
`complex128`	Complex number, represented by two 64-bit floats

More advanced type specification is possible, such as specifying big or little endian numbers; for more information, refer to the NumPy documentation. NumPy also supports compound data types, which will be covered in "Structured Data: NumPy's Structured Arrays" on page 92.