

:mod:`itertools` --- Functions creating iterators for efficient looping

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 1); [backlink](#)

Unknown interpreted text role "mod".

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Unknown directive type "module".

```
.. module:: itertools
   :synopsis: Functions creating iterators for efficient looping.
```

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Unknown directive type "moduleauthor".

```
.. moduleauthor:: Raymond Hettinger <python@rcn.com>
```

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 8)

Unknown directive type "sectionauthor".

```
.. sectionauthor:: Raymond Hettinger <python@rcn.com>
```

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Unknown directive type "testsetup".

```
.. testsetup::
    from itertools import *
```

This module implements a number of `term`iterator`` building blocks inspired by constructs from APL, Haskell, and SML. Each has been recast in a form suitable for Python.

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The module standardizes a core set of fast, memory efficient tools that are useful by themselves or in combination. Together, they form an "iterator algebra" making it possible to construct specialized tools succinctly and efficiently in pure Python.

For instance, SML provides a tabulation tool: `tabulate(f)` which produces a sequence `f(0), f(1), ...`. The same effect can be achieved in Python by combining `func`map`` and `func`count`` to form `map(f, count())`.

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These tools and their built-in counterparts also work well with the high-speed functions in the `mod`operator`` module. For example, the multiplication operator can be mapped across two vectors to form an efficient dot-product: `sum(map(operator.mul, vector1, vector2))`.

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Infinite iterators:

Iterator	Arguments	Results	Example
func: 'count' <div> System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 41); backlink Unknown interpreted text role "func". </div>	start, [step]	start, start+step, start+2*step, ...	count(10) --> 10 11 12 13 14 ...
func: 'cycle' <div> System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 42); backlink Unknown interpreted text role "func". </div>	p	p0, p1, ... plast, p0, p1, ...	cycle('ABCD') --> A B C D A B C D ...
func: 'repeat' <div> System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 43); backlink Unknown interpreted text role "func". </div>	elem[,n]	elem, elem, elem, ... endlessly or up to n times	repeat(10, 3) --> 10 10 10

Iterators terminating on the shortest input sequence:

Iterator	Arguments	Results	Example
func: 'accumulate' <div> System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 51); backlink Unknown interpreted text role "func". </div>	p [,func]	p0, p0+p1, p0+p1+p2, ...	accumulate([1,2,3,4,5]) --> 1 3 6 10 15

Iterator	Arguments	Results	Example
func: 'chain' <div> System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 52); backlink Unknown interpreted text role "func". </div>	p, q, ...	p0, p1, ... plast, q0, q1, ...	chain('ABC', 'DEF') --> A B C D E F
func: 'chain.from_iterable' <div> System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 53); backlink Unknown interpreted text role "func". </div>	iterable	p0, p1, ... plast, q0, q1, ...	chain.from_iterable(['ABC', 'DEF']) --> A B C D E F
func: 'compress' <div> System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 54); backlink Unknown interpreted text role "func". </div>	data, selectors	(d[0] if s[0]), (d[1] if s[1]), ...	compress('ABCDEF', [1,0,1,0,1,1]) --> A C E F
func: 'dropwhile' <div> System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 55); backlink Unknown interpreted text role "func". </div>	pred, seq	seq[n], seq[n+1], starting when pred fails	dropwhile(lambda x: x<5, [1,4,6,4,1]) --> 6 4 1

Iterator	Arguments	Results	Example
func: 'filterfalse' <div> System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 56); backlink Unknown interpreted text role "func". </div>	pred, seq	elements of seq where pred(elem) is false	filterfalse(lambda x: x%2, range(10)) --> 0 2 4 6 8
func: 'groupby' <div> System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 57); backlink Unknown interpreted text role "func". </div>	iterable[, key]	sub-iterators grouped by value of key(v)	
func: 'islice' <div> System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 58); backlink Unknown interpreted text role "func". </div>	seq, [start,] stop [, step]	elements from seq[start:stop:step]	islice('ABCDEFG', 2, None) --> C D E F G
func: 'pairwise' <div> System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 59); backlink Unknown interpreted text role "func". </div>	iterable	(p[0], p[1]), (p[1], p[2])	pairwise('ABCDEFG') --> AB BC CD DE EF FG

Iterator	Arguments	Results	Example
func: 'starmap' <div> System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 60); backlink Unknown interpreted text role "func". </div>	func, seq	func(*seq[0]), func(*seq[1]), ...	starmap(pow, [(2,5), (3,2), (10,3)]) --> 32 9 1000
func: 'takewhile' <div> System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 61); backlink Unknown interpreted text role "func". </div>	pred, seq	seq[0], seq[1], until pred fails	takewhile(lambda x: x<5, [1,4,6,4,1]) --> 1 4
func: 'tee' <div> System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 62); backlink Unknown interpreted text role "func". </div>	it, n	it1, it2, ... itn splits one iterator into n	
func: 'zip_longest' <div> System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 63); backlink Unknown interpreted text role "func". </div>	p, q, ...	(p[0], q[0]), (p[1], q[1]), ...	zip_longest('ABCD', 'xy', fillvalue='-') --> Ax By C- D-

Combinatoric iterators:

Iterator	Arguments	Results
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Iterator	Arguments	Results
System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 71); <i>backlink</i> Unknown interpreted text role "func".	p, q, ... [repeat=1]	cartesian product, equivalent to a nested for-loop
System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 72); <i>backlink</i> Unknown interpreted text role "func".	p[, r]	r-length tuples, all possible orderings, no repeated elements
System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 73); <i>backlink</i> Unknown interpreted text role "func".	p, r	r-length tuples, in sorted order, no repeated elements
System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 74); <i>backlink</i> Unknown interpreted text role "func".	p, r	r-length tuples, in sorted order, with repeated elements

Examples	Results
product('ABCD', repeat=2)	AA AB AC AD BA BB BC BD CA CB CC CD DA DB DC DD
permutations('ABCD', 2)	AB AC AD BA BC BD CA CB CD DA DB DC
combinations('ABCD', 2)	AB AC AD BC BD CD
combinations_with_replacement('ABCD', 2)	AA AB AC AD BB BC BD CC CD DD

Itertool functions

The following module functions all construct and return iterators. Some provide streams of infinite length, so they should only be

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Unknown directive type "function".

```
.. function:: accumulate(iterable[, func, *, initial=None])
```

Make an iterator that returns accumulated sums, or accumulated results of other binary functions (specified via the optional `*func*` argument).

If `*func*` is supplied, it should be a function of two arguments. Elements of the input `*iterable*` may be any type that can be accepted as arguments to `*func*`. (For example, with the default operation of addition, elements may be any addable type including `:class:`~decimal.Decimal`` or `:class:`~fractions.Fraction``.)

Usually, the number of elements output matches the input iterable. However, if the keyword argument `*initial*` is provided, the accumulation leads off with the `*initial*` value so that the output has one more element than the input iterable.

Roughly equivalent to::

```
def accumulate(iterable, func=operator.add, *, initial=None):
    'Return running totals'
    # accumulate([1,2,3,4,5]) --> 1 3 6 10 15
    # accumulate([1,2,3,4,5], initial=100) --> 100 101 103 106 110 115
    # accumulate([1,2,3,4,5], operator.mul) --> 1 2 6 24 120
    it = iter(iterable)
    total = initial
    if initial is None:
        try:
            total = next(it)
        except StopIteration:
            return
    yield total
    for element in it:
        total = func(total, element)
        yield total
```

There are a number of uses for the `*func*` argument. It can be set to `:func:`min`` for a running minimum, `:func:`max`` for a running maximum, or `:func:`operator.mul`` for a running product. Amortization tables can be built by accumulating interest and applying payments. First-order recurrence relations <https://en.wikipedia.org/wiki/Recurrence_relation> can be modeled by supplying the initial value in the iterable and using only the accumulated total in `*func*` argument::

```
>>> data = [3, 4, 6, 2, 1, 9, 0, 7, 5, 8]
>>> list(accumulate(data, operator.mul))      # running product
[3, 12, 72, 144, 144, 1296, 0, 0, 0, 0]
>>> list(accumulate(data, max))               # running maximum
[3, 4, 6, 6, 6, 9, 9, 9, 9, 9]

# Amortize a 5% loan of 1000 with 4 annual payments of 90
>>> cashflows = [1000, -90, -90, -90, -90]
>>> list(accumulate(cashflows, lambda bal, pmt: bal*1.05 + pmt))
[1000, 960.0, 918.0, 873.9000000000001, 827.5950000000001]

# Chaotic recurrence relation https://en.wikipedia.org/wiki/Logistic_map
>>> logistic_map = lambda x, _: r * x * (1 - x)
>>> r = 3.8
>>> x0 = 0.4
>>> inputs = repeat(x0, 36)                  # only the initial value is used
>>> [format(x, '.2f') for x in accumulate(inputs, logistic_map)]
['0.40', '0.91', '0.30', '0.81', '0.60', '0.92', '0.29', '0.79', '0.63',
'0.88', '0.39', '0.90', '0.33', '0.84', '0.52', '0.95', '0.18', '0.57',
'0.93', '0.25', '0.71', '0.79', '0.63', '0.88', '0.39', '0.91', '0.32',
'0.83', '0.54', '0.95', '0.20', '0.60', '0.91', '0.30', '0.80', '0.60']
```

See `:func:`functools.reduce`` for a similar function that returns only the final accumulated value.

```
.. versionadded:: 3.2
```

```
.. versionchanged:: 3.3
   Added the optional *func* parameter.
```

```
.. versionchanged:: 3.8
   Added the optional *initial* parameter.
```

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Unknown directive type "function".

```
.. function:: chain(*iterables)
```

Make an iterator that returns elements from the first iterable until it is exhausted, then proceeds to the next iterable, until all of the iterables are exhausted. Used for treating consecutive sequences as a single sequence. Roughly equivalent to::

```
def chain(*iterables):
    # chain('ABC', 'DEF') --> A B C D E F
    for it in iterables:
        for element in it:
            yield element
```

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Unknown directive type "classmethod".

```
.. classmethod:: chain.from_iterable(iterable)
```

Alternate constructor for :func:`chain`. Gets chained inputs from a single iterable argument that is evaluated lazily. Roughly equivalent to::

```
def from_iterable(iterables):
    # chain.from_iterable(['ABC', 'DEF']) --> A B C D E F
    for it in iterables:
        for element in it:
            yield element
```

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Unknown directive type "function".

```
.. function:: combinations(iterable, r)
```

Return *r* length subsequences of elements from the input *iterable*.

The combination tuples are emitted in lexicographic ordering according to the order of the input *iterable*. So, if the input *iterable* is sorted, the combination tuples will be produced in sorted order.

Elements are treated as unique based on their position, not on their value. So if the input elements are unique, there will be no repeat values in each combination.

Roughly equivalent to::

```
def combinations(iterable, r):
    # combinations('ABCD', 2) --> AB AC AD BC BD CD
    # combinations(range(4), 3) --> 012 013 023 123
    pool = tuple(iterable)
    n = len(pool)
    if r > n:
        return
    indices = list(range(r))
    yield tuple(pool[i] for i in indices)
    while True:
        for i in reversed(range(r)):
            if indices[i] != i + n - r:
                break
        else:
            return
        indices[i] += 1
        for j in range(i+1, r):
            indices[j] = indices[j-1] + 1
        yield tuple(pool[i] for i in indices)
```

The code for :func:`combinations` can be also expressed as a subsequence of :func:`permutations` after filtering entries where the elements are not in sorted order (according to their position in the input pool)::

```
def combinations(iterable, r):
    pool = tuple(iterable)
    n = len(pool)
    for indices in permutations(range(n), r):
        if sorted(indices) == list(indices):
            yield tuple(pool[i] for i in indices)
```

The number of items returned is ``n! / r! / (n-r)!`` when ``0 <= r <= n`` or zero when ``r > n``.

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Unknown directive type "function".


```
.. function:: combinations_with_replacement(iterable, r)
```

Return **r** length subsequences of elements from the input **iterable** allowing individual elements to be repeated more than once.

The combination tuples are emitted in lexicographic ordering according to the order of the input **iterable**. So, if the input **iterable** is sorted, the combination tuples will be produced in sorted order.

Elements are treated as unique based on their position, not on their value. So if the input elements are unique, the generated combinations will also be unique.

Roughly equivalent to::

```
def combinations_with_replacement(iterable, r):
    # combinations_with_replacement('ABC', 2) --> AA AB AC BB BC CC
    pool = tuple(iterable)
    n = len(pool)
    if not n and r:
        return
    indices = [0] * r
    yield tuple(pool[i] for i in indices)
    while True:
        for i in reversed(range(r)):
            if indices[i] != n - 1:
                break
            else:
                return
        indices[i:] = [indices[i] + 1] * (r - i)
        yield tuple(pool[i] for i in indices)
```

The code for `:func:`combinations_with_replacement`` can be also expressed as a subsequence of `:func:`product`` after filtering entries where the elements are not in sorted order (according to their position in the input pool)::

```
def combinations_with_replacement(iterable, r):
    pool = tuple(iterable)
    n = len(pool)
    for indices in product(range(n), repeat=r):
        if sorted(indices) == list(indices):
            yield tuple(pool[i] for i in indices)
```

The number of items returned is $((n+r-1)! / r! / (n-1)!)$ when $n > 0$.

```
.. versionadded:: 3.1
```

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Unknown directive type "function".

```
.. function:: compress(data, selectors)
```

Make an iterator that filters elements from **data** returning only those that have a corresponding element in **selectors** that evaluates to `True`. Stops when either the **data** or **selectors** iterables has been exhausted. Roughly equivalent to::

```
def compress(data, selectors):
    # compress('ABCDEF', [1,0,1,0,1,1]) --> A C E F
    return (d for d, s in zip(data, selectors) if s)
```

```
.. versionadded:: 3.1
```

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Unknown directive type "function".

```
.. function:: count(start=0, step=1)
```

Make an iterator that returns evenly spaced values starting with number **start**. Often used as an argument to `:func:`map`` to generate consecutive data points. Also, used with `:func:`zip`` to add sequence numbers. Roughly equivalent to::

```
def count(start=0, step=1):
    # count(10) --> 10 11 12 13 14 ...
    # count(2.5, 0.5) -> 2.5 3.0 3.5 ...
    n = start
    while True:
        yield n
        n += step
```

When counting with floating point numbers, better accuracy can sometimes be achieved by substituting multiplicative code such as: `((start + step * i for i in count()))`.

```
.. versionchanged:: 3.1
   Added *step* argument and allowed non-integer arguments.
```

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Unknown directive type "function".

```
.. function:: cycle(iterable)
```

Make an iterator returning elements from the iterable and saving a copy of each. When the iterable is exhausted, return elements from the saved copy. Repeats indefinitely. Roughly equivalent to::

```
def cycle(iterable):
    # cycle('ABCD') --> A B C D A B C D A B C D ...
    saved = []
    for element in iterable:
        yield element
        saved.append(element)
    while saved:
        for element in saved:
            yield element
```

Note, this member of the toolkit may require significant auxiliary storage (depending on the length of the iterable).

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Unknown directive type "function".

```
.. function:: dropwhile(predicate, iterable)
```

Make an iterator that drops elements from the iterable as long as the predicate is true; afterwards, returns every element. Note, the iterator does not produce *any* output until the predicate first becomes false, so it may have a lengthy start-up time. Roughly equivalent to::

```
def dropwhile(predicate, iterable):
    # dropwhile(lambda x: x<5, [1,4,6,4,1]) --> 6 4 1
    iterable = iter(iterable)
    for x in iterable:
        if not predicate(x):
            yield x
            break
    for x in iterable:
        yield x
```

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Unknown directive type "function".

```
.. function:: filterfalse(predicate, iterable)
```

Make an iterator that filters elements from iterable returning only those for which the predicate is ``False``. If *predicate* is ``None``, return the items that are false. Roughly equivalent to::

```
def filterfalse(predicate, iterable):
    # filterfalse(lambda x: x%2, range(10)) --> 0 2 4 6 8
    if predicate is None:
        predicate = bool
    for x in iterable:
        if not predicate(x):
            yield x
```

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Unknown directive type "function".

```
.. function:: groupby(iterable, key=None)
```

Make an iterator that returns consecutive keys and groups from the *iterable*. The *key* is a function computing a key value for each element. If not specified or is ``None``, *key* defaults to an identity function and returns the element unchanged. Generally, the iterable needs to already be sorted on the same key function.

The operation of :func:`groupby` is similar to the ``uniq`` filter in Unix. It generates a break or new group every time the value of the key function changes (which is why it is usually necessary to have sorted the data using the same key

function). That behavior differs from SQL's GROUP BY which aggregates common elements regardless of their input order.

The returned group is itself an iterator that shares the underlying iterable with :func:`groupby`. Because the source is shared, when the :func:`groupby` object is advanced, the previous group is no longer visible. So, if that data is needed later, it should be stored as a list::

```
groups = []
uniquekeys = []
data = sorted(data, key=keyfunc)
for k, g in groupby(data, keyfunc):
    groups.append(list(g))      # Store group iterator as a list
    uniquekeys.append(k)
```

:func:`groupby` is roughly equivalent to::

```
class groupby:
    # [k for k, g in groupby('AAAABBBCCDAABBB')] --> A B C D A B
    # [list(g) for k, g in groupby('AAAABBBCCD')] --> AAAA BBB CC D
    def __init__(self, iterable, key=None):
        if key is None:
            key = lambda x: x
        self.keyfunc = key
        self.it = iter(iterable)
        self.tgtkey = self.currkey = self.currvalue = object()
    def __iter__(self):
        return self
    def __next__(self):
        self.id = object()
        while self.currkey == self.tgtkey:
            self.currvalue = next(self.it)      # Exit on StopIteration
            self.currkey = self.keyfunc(self.currvalue)
        self.tgtkey = self.currkey
        return (self.currkey, self._grouper(self.tgtkey, self.id))
    def _grouper(self, tgtkey, id):
        while self.id is id and self.currkey == tgtkey:
            yield self.currvalue
        try:
            self.currvalue = next(self.it)
        except StopIteration:
            return
        self.currkey = self.keyfunc(self.currvalue)
```

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Unknown directive type "function".

```
.. function:: islice(iterable, stop)
           islice(iterable, start, stop[, step])
```

Make an iterator that returns selected elements from the iterable. If *start* is non-zero, then elements from the iterable are skipped until start is reached. Afterward, elements are returned consecutively unless *step* is set higher than one which results in items being skipped. If *stop* is ``None``, then iteration continues until the iterator is exhausted, if at all; otherwise, it stops at the specified position. Unlike regular slicing, :func:`islice` does not support negative values for *start*, *stop*, or *step*. Can be used to extract related fields from data where the internal structure has been flattened (for example, a multi-line report may list a name field on every third line). Roughly equivalent to::

```
def islice(iterable, *args):
    # islice('ABCDEFG', 2) --> A B
    # islice('ABCDEFG', 2, 4) --> C D
    # islice('ABCDEFG', 2, None) --> C D E F G
    # islice('ABCDEFG', 0, None, 2) --> A C E G
    s = slice(*args)
    start, stop, step = s.start or 0, s.stop or sys.maxsize, s.step or 1
    it = iter(range(start, stop, step))
    try:
        nexti = next(it)
    except StopIteration:
        # Consume *iterable* up to the *start* position.
        for i, element in zip(range(start), iterable):
            pass
        return
    try:
        for i, element in enumerate(iterable):
            if i == nexti:
                yield element
                nexti = next(it)
    except StopIteration:
        # Consume to *stop*.
        for i, element in zip(range(i + 1, stop), iterable):
            pass
```

If *start* is ``None``, then iteration starts at zero. If *step* is ``None``, then the step defaults to one.

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 479)

Unknown directive type "function".

```
.. function:: pairwise(iterable)

Return successive overlapping pairs taken from the input *iterable*.

The number of 2-tuples in the output iterator will be one fewer than the
number of inputs. It will be empty if the input iterable has fewer than
two values.

Roughly equivalent to::

    def pairwise(iterable):
        # pairwise('ABCDEFGH') --> AB BC CD DE EF FG
        a, b = tee(iterable)
        next(b, None)
        return zip(a, b)

.. versionadded:: 3.10
```

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 498)

Unknown directive type "function".

```
.. function:: permutations(iterable, r=None)

Return successive *r* length permutations of elements in the *iterable*.

If *r* is not specified or is ``None``, then *r* defaults to the length
of the *iterable* and all possible full-length permutations
are generated.

The permutation tuples are emitted in lexicographic ordering according to
the order of the input *iterable*. So, if the input *iterable* is sorted,
the combination tuples will be produced in sorted order.

Elements are treated as unique based on their position, not on their
value. So if the input elements are unique, there will be no repeat
values in each permutation.

Roughly equivalent to::

    def permutations(iterable, r=None):
        # permutations('ABCD', 2) --> AB AC AD BA BC BD CA CB CD DA DB DC
        # permutations(range(3)) --> 012 021 102 120 201 210
        pool = tuple(iterable)
        n = len(pool)
        r = n if r is None else r
        if r > n:
            return
        indices = list(range(n))
        cycles = list(range(n, n-r, -1))
        yield tuple(pool[i] for i in indices[:r])
        while n:
            for i in reversed(range(r)):
                cycles[i] -= 1
                if cycles[i] == 0:
                    indices[i:] = indices[i+1:] + indices[i:i+1]
                    cycles[i] = n - i
                else:
                    j = cycles[i]
                    indices[i], indices[-j] = indices[-j], indices[i]
                    yield tuple(pool[i] for i in indices[:r])
                    break
            else:
                return

The code for :func:`permutations` can be also expressed as a subsequence of
:func:`product`, filtered to exclude entries with repeated elements (those
from the same position in the input pool)::

    def permutations(iterable, r=None):
        pool = tuple(iterable)
        n = len(pool)
        r = n if r is None else r
        for indices in product(range(n), repeat=r):
            if len(set(indices)) == r:
                yield tuple(pool[i] for i in indices)

The number of items returned is ``n! / (n-r)!`` when ``0 <= r <= n``
or zero when ``r > n``.
```

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 556)

Unknown directive type "function".

```
.. function:: product(*iterables, repeat=1)
```

Cartesian product of input iterables.

Roughly equivalent to nested for-loops in a generator expression. For example, ``product(A, B)`` returns the same as ``(x,y) for x in A for y in B)``.

The nested loops cycle like an odometer with the rightmost element advancing on every iteration. This pattern creates a lexicographic ordering so that if the input's iterables are sorted, the product tuples are emitted in sorted order.

To compute the product of an iterable with itself, specify the number of repetitions with the optional **repeat** keyword argument. For example, ``product(A, repeat=4)`` means the same as ``product(A, A, A, A)``.

This function is roughly equivalent to the following code, except that the actual implementation does not build up intermediate results in memory::

```
def product(*args, repeat=1):
    # product('ABCD', 'xy') --> Ax Ay Bx By Cx Cy Dx Dy
    # product(range(2), repeat=3) --> 000 001 010 011 100 101 110 111
    pools = [tuple(pool) for pool in args] * repeat
    result = [[]]
    for pool in pools:
        result = [x+[y] for x in result for y in pool]
    for prod in result:
        yield tuple(prod)
```

Before `:func:`product`` runs, it completely consumes the input iterables, keeping pools of values in memory to generate the products. Accordingly, it is only useful with finite inputs.

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Unknown directive type "function".

```
.. function:: repeat(object[, times])
```

Make an iterator that returns **object** over and over again. Runs indefinitely unless the **times** argument is specified. Used as argument to `:func:`map`` for invariant parameters to the called function. Also used with `:func:`zip`` to create an invariant part of a tuple record.

Roughly equivalent to::

```
def repeat(object, times=None):
    # repeat(10, 3) --> 10 10 10
    if times is None:
        while True:
            yield object
    else:
        for i in range(times):
            yield object
```

A common use for **repeat** is to supply a stream of constant values to **map** or **zip**::

```
>>> list(map(pow, range(10), repeat(2)))
[0, 1, 4, 9, 16, 25, 36, 49, 64, 81]
```

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 613)

Unknown directive type "function".

```
.. function:: starmap(function, iterable)
```

Make an iterator that computes the function using arguments obtained from the iterable. Used instead of `:func:`map`` when argument parameters are already grouped in tuples from a single iterable (the data has been "pre-zipped"). The difference between `:func:`map`` and `:func:`starmap`` parallels the distinction between `function(a,b)``` and `function(*c)```. Roughly equivalent to::

```
def starmap(function, iterable):
    # starmap(pow, [(2,5), (3,2), (10,3)]) --> 32 9 1000
    for args in iterable:
        yield function(*args)
```

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 627)

Unknown directive type "function".

```
.. function:: takewhile(predicate, iterable)
```

Make an iterator that returns elements from the iterable as long as the predicate is true. Roughly equivalent to::

```
def takewhile(predicate, iterable):
    # takewhile(lambda x: x<5, [1,4,6,4,1]) --> 1 4
    for x in iterable:
        if predicate(x):
            yield x
        else:
            break
```

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 641)

Unknown directive type "function".

```
.. function:: tee(iterable, n=2)
```

Return *n** independent iterators from a single iterable.

The following Python code helps explain what **tee** does (although the actual implementation is more complex and uses only a single underlying :abbr:`FIFO (first-in, first-out)` queue).

Roughly equivalent to::

```
def tee(iterable, n=2):
    it = iter(iterable)
    dequeues = [collections.deque() for i in range(n)]
    def gen(mydeque):
        while True:
            if not mydeque:
                # when the local deque is empty
                try:
                    newval = next(it) # fetch a new value and
                except StopIteration:
                    return
                for d in dequeues:
                    # load it to all the dequeues
                    d.append(newval)
            yield mydeque.popleft()
    return tuple(gen(d) for d in dequeues)
```

Once :func:`tee` has made a split, the original **iterable** should not be used anywhere else; otherwise, the **iterable** could get advanced without the tee objects being informed.

`tee` iterators are not threadsafe. A :exc:`RuntimeError` may be raised when using simultaneously iterators returned by the same :func:`tee` call, even if the original **iterable** is threadsafe.

This itertools may require significant auxiliary storage (depending on how much temporary data needs to be stored). In general, if one iterator uses most or all of the data before another iterator starts, it is faster to use :func:`list` instead of :func:`tee`.

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Unknown directive type "function".

```
.. function:: zip_longest(*iterables, fillvalue=None)
```

Make an iterator that aggregates elements from each of the iterables. If the iterables are of uneven length, missing values are filled-in with **fillvalue**. Iteration continues until the longest iterable is exhausted. Roughly equivalent to::

```
def zip_longest(*args, fillvalue=None):
    # zip_longest('ABCD', 'xy', fillvalue='-') --> Ax By C- D-
    iterators = [iter(it) for it in args]
    num_active = len(iterators)
    if not num_active:
        return
    while True:
        values = []
        for i, it in enumerate(iterators):
            try:
                value = next(it)
            except StopIteration:
                num_active -= 1
                if not num_active:
                    return
                iterators[i] = repeat(fillvalue)
                value = fillvalue
            values.append(value)
        yield tuple(values)
```

If one of the iterables is potentially infinite, then the :func:`zip_longest`

```
function should be wrapped with something that limits the number of calls
(for example :func:`islice` or :func:`takewhile`). If not specified,
*fillvalue* defaults to ``None``.
```

Itertools Recipes

This section shows recipes for creating an extended toolset using the existing itertools as building blocks.

Substantially all of these recipes and many, many others can be installed from the [more-itertools project](#) found on the Python Package Index:

```
pip install more-itertools
```

The extended tools offer the same high performance as the underlying toolset. The superior memory performance is kept by processing elements one at a time rather than bringing the whole iterable into memory all at once. Code volume is kept small by linking the tools together in a functional style which helps eliminate temporary variables. High speed is retained by preferring "vectorized" building blocks over the use of for-loops and `term` generator's which incur interpreter overhead.

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 726); [backlink](#)

Unknown interpreted text role "term".

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\ (cpython-main) (Doc) (library) itertools.rst, line 734)

Unknown directive type "testcode".

```
.. testcode::

def take(n, iterable):
    "Return first n items of the iterable as a list"
    return list(islice(iterable, n))

def prepend(value, iterator):
    "Prepend a single value in front of an iterator"
    # prepend(1, [2, 3, 4]) -> 1 2 3 4
    return chain([value], iterator)

def tabulate(function, start=0):
    "Return function(0), function(1), ..."
    return map(function, count(start))

def tail(n, iterable):
    "Return an iterator over the last n items"
    # tail(3, 'ABCDEFG') --> E F G
    return iter(collections.deque(iterable, maxlen=n))

def consume(iterator, n=None):
    "Advance the iterator n-steps ahead. If n is None, consume entirely."
    # Use functions that consume iterators at C speed.
    if n is None:
        # feed the entire iterator into a zero-length deque
        collections.deque(iterator, maxlen=0)
    else:
        # advance to the empty slice starting at position n
        next(islice(iterator, n, n), None)

def nth(iterable, n, default=None):
    "Returns the nth item or a default value"
    return next(islice(iterable, n, None), default)

def all_equal(iterable):
    "Returns True if all the elements are equal to each other"
    g = groupby(iterable)
    return next(g, True) and not next(g, False)

def quantify(iterable, pred=bool):
    "Count how many times the predicate is true"
    return sum(map(pred, iterable))

def pad_none(iterable):
    """Returns the sequence elements and then returns None indefinitely.

    Useful for emulating the behavior of the built-in map() function.
    """
    return chain(iterable, repeat(None))

def ncycles(iterable, n):
    "Returns the sequence elements n times"
    return chain.from_iterable(repeat(tuple(iterable), n))

def dotproduct(vec1, vec2):
    return sum(map(operator.mul, vec1, vec2))

def convolve(signal, kernel):
    # See: https://betterexplained.com/articles/intuitive-convolution/
    # convolve(data, [0.25, 0.25, 0.25, 0.25]) --> Moving average (blur)
```

```

# convolve(data, [1, -1]) --> 1st finite difference (1st derivative)
# convolve(data, [1, -2, 1]) --> 2nd finite difference (2nd derivative)
kernel = tuple(kernel)[::-1]
n = len(kernel)
window = collections.deque([0], maxlen=n) * n
for x in chain(signal, repeat(0, n-1)):
    window.append(x)
    yield sum(map(operator.mul, kernel, window))

def flatten(list_of_lists):
    "Flatten one level of nesting"
    return chain.from_iterable(list_of_lists)

def repeatfunc(func, times=None, *args):
    """Repeat calls to func with specified arguments.

    Example:  repeatfunc(random.random)
    """
    if times is None:
        return starmap(func, repeat(args))
    return starmap(func, repeat(args, times))

def grouper(iterable, n, *, incomplete='fill', fillvalue=None):
    "Collect data into non-overlapping fixed-length chunks or blocks"
    # grouper('ABCDEFG', 3, fillvalue='x') --> ABC DEF Gxx
    # grouper('ABCDEFG', 3, incomplete='strict') --> ABC DEF ValueError
    # grouper('ABCDEFG', 3, incomplete='ignore') --> ABC DEF
    args = [iter(iterable)] * n
    if incomplete == 'fill':
        return zip_longest(*args, fillvalue=fillvalue)
    if incomplete == 'strict':
        return zip(*args, strict=True)
    if incomplete == 'ignore':
        return zip(*args)
    else:
        raise ValueError('Expected fill, strict, or ignore')

def triplewise(iterable):
    "Return overlapping triplets from an iterable"
    # triplewise('ABCDEFG') --> ABC BCD CDE DEF EFG
    for (a, _), (b, c) in pairwise(pairwise(iterable)):
        yield a, b, c

def sliding_window(iterable, n):
    # sliding_window('ABCDEFG', 4) --> ABCD BCDE CDEF DEFG
    it = iter(iterable)
    window = collections.deque(islice(it, n), maxlen=n)
    if len(window) == n:
        yield tuple(window)
    for x in it:
        window.append(x)
        yield tuple(window)

def roundrobin(*iterables):
    "roundrobin('ABC', 'D', 'EF') --> A D E B F C"
    # Recipe credited to George Sakkis
    num_active = len(iterables)
    nexts = cycle(iter(it).__next__ for it in iterables)
    while num_active:
        try:
            for next in nexts:
                yield next()
        except StopIteration:
            # Remove the iterator we just exhausted from the cycle.
            num_active -= 1
            nexts = cycle(islice(nexts, num_active))

def partition(pred, iterable):
    "Use a predicate to partition entries into false entries and true entries"
    # partition(is_odd, range(10)) --> 0 2 4 6 8   and  1 3 5 7 9
    t1, t2 = tee(iterable)
    return filterfalse(pred, t1), filter(pred, t2)

def before_and_after(predicate, it):
    """ Variant of takewhile() that allows complete
        access to the remainder of the iterator.

    >>> it = iter('ABCdEfGhI')
    >>> all_upper, remainder = before_and_after(str.isupper, it)
    >>> ''.join(all_upper)
    'ABC'
    >>> ''.join(remainder)      # takewhile() would lose the 'd'
    'dEfGhI'

    Note that the first iterator must be fully
    consumed before the second iterator can
    generate valid results.
    """
    it = iter(it)
    transition = []
    def true_iterator():
        for elem in it:
            if predicate(elem):
                yield elem

```



```

        else:
            transition.append(elem)
            return
    def remainder_iterator():
        yield from transition
        yield from it
    return true_iterator(), remainder_iterator()

def subslices(seq):
    "Return all contiguous non-empty subslices of a sequence"
    # subslices('ABCD') --> A AB ABC ABCD B BC BCD C CD D
    slices = starmap(slice, combinations(range(len(seq) + 1), 2))
    return map(operator.getitem, repeat(seq), slices)

def powerset(iterable):
    "powerset([1,2,3]) --> () (1,) (2,) (3,) (1,2) (1,3) (2,3) (1,2,3)"
    s = list(iterable)
    return chain.from_iterable(combinations(s, r) for r in range(len(s)+1))

def unique_everseen(iterable, key=None):
    "List unique elements, preserving order. Remember all elements ever seen."
    # unique_everseen('AAAABBBCCDAABBB') --> A B C D
    # unique_everseen('ABBCcAD', str.lower) --> A B C D
    seen = set()
    seen_add = seen.add
    if key is None:
        for element in filterfalse(seen.__contains__, iterable):
            seen_add(element)
            yield element
    else:
        for element in iterable:
            k = key(element)
            if k not in seen:
                seen_add(k)
                yield element

def unique_justseen(iterable, key=None):
    "List unique elements, preserving order. Remember only the element just seen."
    # unique_justseen('AAAABBBCCDAABBB') --> A B C D A B
    # unique_justseen('ABBCcAD', str.lower) --> A B C A D
    return map(next, map(operator.itemgetter(1), groupby(iterable, key)))

def iter_except(func, exception, first=None):
    """ Call a function repeatedly until an exception is raised.

    Converts a call-until-exception interface to an iterator interface.
    Like builtins.iter(func, sentinel) but uses an exception instead
    of a sentinel to end the loop.

    Examples:
    iter_except(functools.partial(heapop, h), IndexError) # priority queue iterator
    iter_except(d.popitem, KeyError) # non-blocking dict iterator
    iter_except(d.popleft, IndexError) # non-blocking deque iterator
    iter_except(q.get_nowait, Queue.Empty) # loop over a producer Queue
    iter_except(s.pop, KeyError) # non-blocking set iterator

    """
    try:
        if first is not None:
            yield first() # For database APIs needing an initial cast to db.first()
        while True:
            yield func()
    except exception:
        pass

def first_true(iterable, default=False, pred=None):
    """Returns the first true value in the iterable.

    If no true value is found, returns *default*

    If *pred* is not None, returns the first item
    for which pred(item) is true.

    """
    # first_true([a,b,c], x) --> a or b or c or x
    # first_true([a,b], x, f) --> a if f(a) else b if f(b) else x
    return next(filter(pred, iterable), default)

def random_product(*args, repeat=1):
    "Random selection from itertools.product(*args, **kwargs)"
    pools = [tuple(pool) for pool in args] * repeat
    return tuple(map(random.choice, pools))

def random_permutation(iterable, r=None):
    "Random selection from itertools.permutations(iterable, r)"
    pool = tuple(iterable)
    r = len(pool) if r is None else r
    return tuple(random.sample(pool, r))

def random_combination(iterable, r):
    "Random selection from itertools.combinations(iterable, r)"
    pool = tuple(iterable)
    n = len(pool)
    indices = sorted(random.sample(range(n), r))

```

```

        return tuple(pool[i] for i in indices)

def random_combination_with_replacement(iterable, r):
    "Random selection from itertools.combinations_with_replacement(iterable, r)"
    pool = tuple(iterable)
    n = len(pool)
    indices = sorted(random.choices(range(n), k=r))
    return tuple(pool[i] for i in indices)

def nth_combination(iterable, r, index):
    "Equivalent to list(combinations(iterable, r))[index]"
    pool = tuple(iterable)
    n = len(pool)
    if r < 0 or r > n:
        raise ValueError
    c = 1
    k = min(r, n-r)
    for i in range(1, k+1):
        c = c * (n - k + i) // i
    if index < 0:
        index += c
    if index < 0 or index >= c:
        raise IndexError
    result = []
    while r:
        c, n, r = c*r//n, n-1, r-1
        while index >= c:
            index -= c
            c, n = c*(n-r)//n, n-1
        result.append(pool[-1-n])
    return tuple(result)

```

System Message: ERROR/3 (D:\onboarding-resources\sample-onboarding-resources\cpython-main\Doc\library\cpython-main) (Doc) (library)itertools.rst, line 1014)

Unknown directive type "doctest".

```

.. doctest::
   :hide:

   These examples no longer appear in the docs but are guaranteed
   to keep working.

   >>> amounts = [120.15, 764.05, 823.14]
   >>> for checknum, amount in zip(count(1200), amounts):
   ...     print('Check %d is for $%.2f' % (checknum, amount))
   ...
   Check 1200 is for $120.15
   Check 1201 is for $764.05
   Check 1202 is for $823.14

   >>> import operator
   >>> for cube in map(operator.pow, range(1,4), repeat(3)):
   ...     print(cube)
   ...
   1
   8
   27

   >>> reportlines = ['EuroPython', 'Roster', '', 'alex', '', 'laura', '', 'martin', '', 'walter', '', 'samuele']
   >>> for name in islice(reportlines, 3, None, 2):
   ...     print(name.title())
   ...
   Alex
   Laura
   Martin
   Walter
   Samuele

   >>> from operator import itemgetter
   >>> d = dict(a=1, b=2, c=1, d=2, e=1, f=2, g=3)
   >>> di = sorted(sorted(d.items()), key=itemgetter(1))
   >>> for k, g in groupby(di, itemgetter(1)):
   ...     print(k, list(map(itemgetter(0), g)))
   ...
   1 ['a', 'c', 'e']
   2 ['b', 'd', 'f']
   3 ['g']

   # Find runs of consecutive numbers using groupby. The key to the solution
   # is differencing with a range so that consecutive numbers all appear in
   # same group.
   >>> data = [ 1, 4, 5, 6, 10, 15, 16, 17, 18, 22, 25, 26, 27, 28]
   >>> for k, g in groupby(enumerate(data), lambda t:t[0]-t[1]):
   ...     print(list(map(operator.itemgetter(1), g)))
   ...
   [1]
   [4, 5, 6]
   [10]
   [15, 16, 17, 18]
   [22]
   [25, 26, 27, 28]

```

Now, we test all of the itertools recipes

```
>>> import operator
>>> import collections

>>> take(10, count())
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]

>>> list(prepend(1, [2, 3, 4]))
[1, 2, 3, 4]

>>> list(enumerate('abc'))
[(0, 'a'), (1, 'b'), (2, 'c')]

>>> list(islice(tabulate(lambda x: 2*x), 4))
[0, 2, 4, 6]

>>> list(tail(3, 'ABCDEFGH'))
['E', 'F', 'G']

>>> it = iter(range(10))
>>> consume(it, 3)
>>> next(it)
3
>>> consume(it)
>>> next(it, 'Done')
'Done'

>>> nth('abcde', 3)
'd'

>>> nth('abcde', 9) is None
True

>>> [all_equal(s) for s in ('', 'A', 'AAAA', 'AAAB', 'AAABA')]
[True, True, True, False, False]

>>> quantify(range(99), lambda x: x%2==0)
50

>>> quantify([True, False, False, True, True])
3

>>> quantify(range(12), pred=lambda x: x%2==1)
6

>>> a = [[1, 2, 3], [4, 5, 6]]
>>> list(flatten(a))
[1, 2, 3, 4, 5, 6]

>>> list(repeatfunc(pow, 5, 2, 3))
[8, 8, 8, 8, 8]

>>> import random
>>> take(5, map(int, repeatfunc(random.random)))
[0, 0, 0, 0, 0]

>>> list(islice(pad_none('abc'), 0, 6))
['a', 'b', 'c', None, None, None]

>>> list(ncycles('abc', 3))
['a', 'b', 'c', 'a', 'b', 'c', 'a', 'b', 'c']

>>> dotproduct([1,2,3], [4,5,6])
32

>>> data = [20, 40, 24, 32, 20, 28, 16]
>>> list(convolve(data, [0.25, 0.25, 0.25, 0.25]))
[5.0, 15.0, 21.0, 29.0, 29.0, 26.0, 24.0, 16.0, 11.0, 4.0]
>>> list(convolve(data, [1, -1]))
[20, 20, -16, 8, -12, 8, -12, -16]
>>> list(convolve(data, [1, -2, 1]))
[20, 0, -36, 24, -20, 20, -20, -4, 16]

>>> list(flatten([( 'a', 'b'), (), ('c', 'd', 'e'), ('f',), ('g', 'h', 'i'))])
['a', 'b', 'c', 'd', 'e', 'f', 'g', 'h', 'i']

>>> import random
>>> random.seed(85753098575309)
>>> list(repeatfunc(random.random, 3))
[0.16370491282496968, 0.45889608687313455, 0.3747076837820118]
>>> list(repeatfunc(chr, 3, 65))
['A', 'A', 'A']
>>> list(repeatfunc(pow, 3, 2, 5))
[32, 32, 32]

>>> list(grouper('abcdefg', 3, fillvalue='x'))
[('a', 'b', 'c'), ('d', 'e', 'f'), ('g', 'x', 'x')]

>>> it = grouper('abcdefg', 3, incomplete='strict')
>>> next(it)
('a', 'b', 'c')
>>> next(it)
```

```

('d', 'e', 'f')
>>> next(it)
Traceback (most recent call last):
...
ValueError: zip() argument 2 is shorter than argument 1

>>> list(grouper('abcdefg', n=3, incomplete='ignore'))
[('a', 'b', 'c'), ('d', 'e', 'f')]

>>> list(triplewise('ABCDEFG'))
[('A', 'B', 'C'), ('B', 'C', 'D'), ('C', 'D', 'E'), ('D', 'E', 'F'), ('E', 'F', 'G')]

>>> list(sliding_window('ABCDEFG', 4))
[('A', 'B', 'C', 'D'), ('B', 'C', 'D', 'E'), ('C', 'D', 'E', 'F'), ('D', 'E', 'F', 'G')]

>>> list(roundrobin('abc', 'd', 'ef'))
['a', 'd', 'e', 'b', 'f', 'c']

>>> def is_odd(x):
...     return x % 2 == 1

>>> evens, odds = partition(is_odd, range(10))
>>> list(evens)
[0, 2, 4, 6, 8]
>>> list(odds)
[1, 3, 5, 7, 9]

>>> it = iter('ABCdEfGhI')
>>> all_upper, remainder = before_and_after(str.isupper, it)
>>> ''.join(all_upper)
'ABC'
>>> ''.join(remainder)
'dEfGhI'

>>> list(subslices('ABCD'))
['A', 'AB', 'ABC', 'ABCD', 'B', 'BC', 'BCD', 'C', 'CD', 'D']

>>> list(powerset([1,2,3]))
[(), (1,), (2,), (3,), (1, 2), (1, 3), (2, 3), (1, 2, 3)]

>>> all(len(list(powerset(range(n)))) == 2**n for n in range(18))
True

>>> list(powerset('abcde')) == sorted(sorted(set(powerset('abcde'))), key=len)
True

>>> list(unique_everseen('AAAABBBCCDAABBB'))
['A', 'B', 'C', 'D']

>>> list(unique_everseen('ABBCcAD', str.lower))
['A', 'B', 'C', 'D']

>>> list(unique_justseen('AAAABBBCCDAABBB'))
['A', 'B', 'C', 'D', 'A', 'B']

>>> list(unique_justseen('ABBCcAD', str.lower))
['A', 'B', 'C', 'A', 'D']

>>> d = dict(a=1, b=2, c=3)
>>> it = iter_except(d.popitem, KeyError)
>>> d['d'] = 4
>>> next(it)
('d', 4)
>>> next(it)
('c', 3)
>>> next(it)
('b', 2)
>>> d['e'] = 5
>>> next(it)
('e', 5)
>>> next(it)
('a', 1)
>>> next(it, 'empty')
'empty'

>>> first_true('ABCODEF1', '9', str.isdigit)
'0'

>>> population = 'ABCDEFGH'
>>> for r in range(len(population) + 1):
...     seq = list(combinations(population, r))
...     for i in range(len(seq)):
...         assert nth_combination(population, r, i) == seq[i]
...     for i in range(-len(seq), 0):
...         assert nth_combination(population, r, i) == seq[i]

>>> iterable = 'abcde'
>>> r = 3
>>> combos = list(combinations(iterable, r))
>>> all(nth_combination(iterable, r, i) == comb for i, comb in enumerate(combos))
True

```