
What's New in Python

Release 3.10.0a3

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Release 3.10.0a3

Date January 04, 2021

This article explains the new features in Python 3.10, compared to 3.9.

For full details, see the changelog.

Note: Prerelease users should be aware that this document is currently in draft form. It will be updated substantially as Python 3.10 moves towards release, so it's worth checking back even after reading earlier versions.

1 Summary – Release highlights

2 New Features

2.1 PEP 563: Postponed Evaluation of Annotations Becomes Default

In Python 3.7, postponed evaluation of annotations was added, to be enabled with a `from __future__ import annotations` directive. In 3.10 this became the default behavior, even without that future directive. With this being default, all annotations stored in `__annotations__` will be strings. If needed, annotations can be resolved at runtime using `typing.get_type_hints()`. See [PEP 563](#) for a full description. Also, the `inspect.signature()` will try to resolve types from now on, and when it fails it will fall back to showing the string annotations. (Contributed by Batuhan Taskaya in [bpo-38605](#).)

- The `int` type has a new method `int.bit_count()`, returning the number of ones in the binary expansion of a given integer, also known as the population count. (Contributed by Niklas Fiekas in [bpo-29882](#).)
- The views returned by `dict.keys()`, `dict.values()` and `dict.items()` now all have a mapping attribute that gives a `types.MappingProxyType` object wrapping the original dictionary. (Contributed by Dennis Sweeney in [bpo-40890](#).)
- **PEP 618:** The `zip()` function now has an optional `strict` flag, used to require that all the iterables have an equal length.

2.2 PEP 613: TypeAlias Annotation

PEP 484 introduced the concept of type aliases, only requiring them to be top-level unannotated assignments. This simplicity sometimes made it difficult for type checkers to distinguish between type aliases and ordinary assignments, especially when forward references or invalid types were involved. Compare:

```
StrCache = 'Cache[str]' # a type alias
LOG_PREFIX = 'LOG[DEBUG]' # a module constant
```

Now the `typing` module has a special annotation `TypeAlias` to declare type aliases more explicitly:

```
StrCache: TypeAlias = 'Cache[str]' # a type alias
LOG_PREFIX = 'LOG[DEBUG]' # a module constant
```

See **PEP 613** for more details.

(Contributed by Mikhail Golubev in [bpo-41923](#).)

2.3 PEP 604: New Type Union Operator

A new type union operator was introduced which enables the syntax `X | Y`. This provides a cleaner way of expressing ‘either type `X` or type `Y`’ instead of using `typing.Union`, especially in type hints (annotations).

In previous versions of Python, to apply a type hint for functions accepting arguments of multiple types, `typing.Union` was used:

```
def square(number: Union[int, float]) -> Union[int, float]:
    return number ** 2
```

Type hints can now be written in a more succinct manner:

```
def square(number: int | float) -> int | float:
    return number ** 2
```

See **PEP 604** for more details.

(Contributed by Maggie Moss and Philippe Prados in [bpo-41428](#).)

2.4 PEP 612: Parameter Specification Variables

Two new options to improve the information provided to static type checkers for **PEP 484**’s `Callable` have been added to the `typing` module.

The first is the parameter specification variable. They are used to forward the parameter types of one callable to another callable – a pattern commonly found in higher order functions and decorators. Examples of usage can be found in `typing.ParamSpec`. Previously, there was no easy way to type annotate dependency of parameter types in such a precise manner.

The second option is the new `Concatenate` operator. It’s used in conjunction with parameter specification variables to type annotate a higher order callable which adds or removes parameters of another callable. Examples of usage can be found in `typing.Concatenate`.

See `typing.Callable`, `typing.ParamSpec`, `typing.Concatenate` and **PEP 612** for more details.

(Contributed by Ken Jin in [bpo-41559](#).)

3 Other Language Changes

- Builtin and extension functions that take integer arguments no longer accept `Decimals`, `Fractions` and other objects that can be converted to integers only with a loss (e.g. that have the `__int__()` method but do not have the `__index__()` method). (Contributed by Serhiy Storchaka in [bpo-37999](#).)
- Assignment expressions can now be used unparenthesized within set literals and set comprehensions, as well as in sequence indexes (but not slices).

4 New Modules

- None yet.

5 Improved Modules

5.1 base64

Add `base64.b32hexencode()` and `base64.b32hexdecode()` to support the Base32 Encoding with Extended Hex Alphabet.

5.2 codecs

Add a `codecs.unregister()` function to unregister a codec search function. (Contributed by Hai Shi in [bpo-41842](#).)

5.3 collections.abc

The `__args__` of the parameterized generic for `collections.abc.Callable` are now consistent with `typing.Callable`. `collections.abc.Callable` generic now flattens type parameters, similar to what `typing.Callable` currently does. This means that `collections.abc.Callable[[int, str], str]` will have `__args__` of `(int, str, str)`; previously this was `([int, str], str)`. To allow this change, `types.GenericAlias` can now be subclassed, and a subclass will be returned when subscripting the `collections.abc.Callable` type. Note that a `TypeError` may be raised for invalid forms of parameterizing `collections.abc.Callable` which may have passed silently in Python 3.9. (Contributed by Ken Jin in [bpo-42195](#).)

5.4 contextlib

Add a `contextlib.aclosing()` context manager to safely close async generators and objects representing asynchronously released resources. (Contributed by Joongi Kim and John Belmonte in [bpo-41229](#).)

Add asynchronous context manager support to `contextlib.nullcontext()`. (Contributed by Tom Gringauz in [bpo-41543](#).)

5.5 curses

The extended color functions added in ncurses 6.1 will be used transparently by `curses.color_content()`, `curses.init_color()`, `curses.init_pair()`, and `curses.pair_content()`. A new function, `curses.has_extended_color_support()`, indicates whether extended color support is provided by the underlying ncurses library. (Contributed by Jeffrey Kintscher and Hans Petter Jansson in [bpo-36982](#).)

5.6 doctest

When a module does not define `__loader__`, fall back to `__spec__.loader`. (Contributed by Brett Cannon in [bpo-42133](#).)

5.7 encodings

`encodings.normalize_encoding()` now ignores non-ASCII characters. (Contributed by Hai Shi in [bpo-39337](#).)

5.8 glob

Added the `root_dir` and `dir_fd` parameters in `glob()` and `iglob()` which allow to specify the root directory for searching. (Contributed by Serhiy Storchaka in [bpo-38144](#).)

5.9 inspect

When a module does not define `__loader__`, fall back to `__spec__.loader`. (Contributed by Brett Cannon in [bpo-42133](#).)

Added `globalns` and `localns` parameters in `signature()` and `inspect.Signature.from_callable()` to retrieve the annotations in given local and global namespaces. (Contributed by Batuhan Taskaya in [bpo-41960](#).)

5.10 linecache

When a module does not define `__loader__`, fall back to `__spec__.loader`. (Contributed by Brett Cannon in [bpo-42133](#).)

5.11 os

Added `os.cpu_count()` support for VxWorks RTOS. (Contributed by Peixing Xin in [bpo-41440](#).)

Added a new function `os.eventfd()` and related helpers to wrap the `eventfd2` syscall on Linux. (Contributed by Christian Heimes in [bpo-41001](#).)

Added `os.splice()` that allows to move data between two file descriptors without copying between kernel address space and user address space, where one of the file descriptors must refer to a pipe. (Contributed by Pablo Galindo in [bpo-41625](#).)

5.12 pathlib

Added slice support to `PurePath.parents`. (Contributed by Joshua Cannon in [bpo-35498](#))

Added negative indexing support to `PurePath.parents`. (Contributed by Yaroslav Pankovych in [bpo-21041](#))

5.13 platform

Added `platform.freedesktop_os_release()` to retrieve operation system identification from [freedesktop.org os-release](#) standard file. (Contributed by Christian Heimes in [bpo-28468](#))

5.14 py_compile

Added `--quiet` option to command-line interface of `py_compile`. (Contributed by Gregory Schevchenko in [bpo-38731](#).)

5.15 shelve

The `shelve` module now uses `pickle.DEFAULT_PROTOCOL` by default instead of `pickle` protocol 3 when creating shelves. (Contributed by Zackery Spytz in [bpo-34204](#).)

5.16 site

When a module does not define `__loader__`, fall back to `__spec__.loader`. (Contributed by Brett Cannon in [bpo-42133](#).)

5.17 socket

The exception `socket.timeout` is now an alias of `TimeoutError`. (Contributed by Christian Heimes in [bpo-42413](#).)

5.18 sys

Add `sys.orig_argv` attribute: the list of the original command line arguments passed to the Python executable. (Contributed by Victor Stinner in [bpo-23427](#).)

5.19 threading

Added `threading.gettrace()` and `threading.getprofile()` to retrieve the functions set by `threading.settrace()` and `threading.setprofile()` respectively. (Contributed by Mario Corchero in [bpo-42251](#).)

Add `threading.__excepthook__` to allow retrieving the original value of `threading.excepthook()` in case it is set to a broken or a different value. (Contributed by Mario Corchero in [bpo-42308](#).)

5.20 traceback

The `format_exception()`, `format_exception_only()`, and `print_exception()` functions can now take an exception object as a positional-only argument. (Contributed by Zackery Spytz and Matthias Bussonnier in [bpo-26389](#).)

5.21 types

Reintroduced the `types.EllipsisType`, `types.NoneType` and `types.NotImplementedType` classes, providing a new set of types readily interpretable by type checkers. (Contributed by Bas van Beek in [bpo-41810](#).)

5.22 typing

The behavior of `typing.Literal` was changed to conform with [PEP 586](#) and to match the behavior of static type checkers specified in the PEP.

1. `Literal` now de-duplicates parameters.
2. Equality comparisons between `Literal` objects are now order independent.
3. `Literal` comparisons now respects types. For example, `Literal[0] == Literal[False]` previously evaluated to `True`. It is now `False`. To support this change, the internally used type cache now supports differentiating types.
4. `Literal` objects will now raise a `TypeError` exception during equality comparisons if one of their parameters are not immutable. Note that declaring `Literal` with mutable parameters will not throw an error:

```
>>> from typing import Literal
>>> Literal[{0}]
>>> Literal[{0}] == Literal[{False}]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: unhashable type: 'set'
```

(Contributed by Yurii Karabas in [bpo-42345](#).)

5.23 unittest

Add new method `assertNoLogs()` to complement the existing `assertLogs()`. (Contributed by Kit Yan Choi in [bpo-39385](#).)

5.24 xml

Add a `LexicalHandler` class to the `xml.sax.handler` module. (Contributed by Jonathan Gossage and Zackery Spytz in [bpo-35018](#).)

5.25 zipimport

Add methods related to [PEP 451](#): `find_spec()`, `zipimport.zipimporter.create_module()`, and `zipimport.zipimporter.exec_module()`. (Contributed by Brett Cannon in [bpo-42131](#).)

6 Optimizations

- Constructors `str()`, `bytes()` and `bytearray()` are now faster (around 30–40% for small objects). (Contributed by Serhiy Storchaka in [bpo-41334](#).)
- The `runpy` module now imports fewer modules. The `python3 -m module-name` command startup time is 1.3x faster in average. (Contributed by Victor Stinner in [bpo-41006](#).)
- The `LOAD_ATTR` instruction now uses new “per opcode cache” mechanism. It is about 36% faster now. This makes optimized `LOAD_ATTR` instructions the current most performance attribute access method (faster than slots). (Contributed by Pablo Galindo and Yury Selivanov in [bpo-42093](#), based on ideas implemented originally in PyPy and MicroPython.)
- When building Python with `--enable-optimizations` now `-fno-semantic-interposition` is added to both the compile and link line. This speeds builds of the Python interpreter created with `--enable-shared` with `gcc` by up to 30%. See [this article](#) for more details. (Contributed by Victor Stinner and Pablo Galindo in [bpo-38980](#).)
- Function parameters and their annotations are no longer computed at runtime, but rather at compilation time. They are stored as a tuple of strings at the bytecode level. It is now around 100% faster to create a function with parameter annotations. (Contributed by Yurii Karabas and Inada Naoki in [bpo-42202](#).)

7 Deprecated

- Starting in this release, there will be a concerted effort to begin cleaning up old import semantics that were kept for Python 2.7 compatibility. Specifically, `find_loader()/find_module()` (superseded by `find_spec()`), `load_module()` (superseded by `exec_module()`), `module_repr()` (which the import system takes care of for you), the `__package__` attribute (superseded by `__spec__.parent`), the `__loader__` attribute (superseded by `__spec__.loader`), and the `__cached__` attribute (superseded by `__spec__.cached`) will slowly be removed (as well as other classes and methods in `importlib`). `ImportWarning` and/or `DeprecationWarning` will be raised as appropriate to help identify code which needs updating during this transition.
- The various `load_module()` methods of `importlib` have been documented as deprecated since Python 3.6, but will now also trigger a `DeprecationWarning`. Use `exec_module()` instead. (Contributed by Brett Cannon in [bpo-26131](#).)
- `zipimport.zipimporter.load_module()` has been deprecated in preference for `exec_module()`. (Contributed by Brett Cannon in [bpo-26131](#).)
- The use of `load_module()` by the import system now triggers an `ImportWarning` as `exec_module()` is preferred. (Contributed by Brett Cannon in [bpo-26131](#).)
- `sqlite3.OptimizedUnicode` has been undocumented and obsolete since Python 3.3, when it was made an alias to `str`. It is now deprecated, scheduled for removal in Python 3.12. (Contributed by Erlend E. Aasland in [bpo-42264](#).)

8 Removed

- Removed special methods `__int__`, `__float__`, `__floordiv__`, `__mod__`, `__divmod__`, `__rfloordiv__`, `__rmod__` and `__rdivmod__` of the `complex` class. They always raised a `TypeError`. (Contributed by Serhiy Storchaka in [bpo-41974](#).)
- The `ParserBase.error()` method from the private and undocumented `_markupbase` module has been removed. `html.parser.HTMLParser` is the only subclass of `ParserBase` and its `error()` implementation has already been removed in Python 3.5. (Contributed by Berker Peksag in [bpo-31844](#).)
- Removed the `unicodedata.ucnhash_CAPI` attribute which was an internal `PyCapsule` object. The related private `_PyUnicode_Name_CAPI` structure was moved to the internal C API. (Contributed by Victor Stinner in [bpo-42157](#).)
- Removed the `parser` module, which was deprecated in 3.9 due to the switch to the new PEG parser, as well as all the C source and header files that were only being used by the old parser, including `node.h`, `parser.h`, `graminit.h` and `grammar.h`.
- Removed the Public C API functions `PyParser_SimpleParseStringFlags()`, `PyParser_SimpleParseStringFlagsFilename()`, `PyParser_SimpleParseFileFlags()` and `PyNode_Compile()` that were deprecated in 3.9 due to the switch to the new PEG parser.
- Removed the `formatter` module, which was deprecated in Python 3.4. It is somewhat obsolete, little used, and not tested. It was originally scheduled to be removed in Python 3.6, but such removals were delayed until after Python 2.7 EOL. Existing users should copy whatever classes they use into their code. (Contributed by Dong-hee Na and Terry J. Reedy in [bpo-42299](#).)
- Removed the `PyModule_GetWarningsModule()` function that was useless now due to the `_warnings` module was converted to a builtin module in 2.6. (Contributed by Hai Shi in [bpo-42599](#).)

9 Porting to Python 3.10

This section lists previously described changes and other bugfixes that may require changes to your code.

9.1 Changes in the Python API

- The *etype* parameters of the `format_exception()`, `format_exception_only()`, and `print_exception()` functions in the `traceback` module have been renamed to *exc*. (Contributed by Zackery Spytz and Matthias Bussonnier in [bpo-26389](#).)
- `atexit`: At Python exit, if a callback registered with `atexit.register()` fails, its exception is now logged. Previously, only some exceptions were logged, and the last exception was always silently ignored. (Contributed by Victor Stinner in [bpo-42639](#).)
- `collections.abc.Callable` generic now flattens type parameters, similar to what `typing.Callable` currently does. This means that `collections.abc.Callable[[int, str], str]` will have `__args__` of `(int, str, str)`; previously this was `([int, str], str)`. Code which accesses the arguments via `typing.get_args()` or `__args__` need to account for this change. Furthermore, `TypeError` may be raised for invalid forms of parameterizing `collections.abc.Callable` which may have passed silently in Python 3.9. (Contributed by Ken Jin in [bpo-42195](#).)
- `socket.htons()` and `socket.ntohs()` now raise `OverflowError` instead of `DeprecationWarning` if the given parameter will not fit in a 16-bit unsigned integer. (Contributed by Erlend E. Aasland in [bpo-42393](#).)

10 CPython bytecode changes

- The `MAKE_FUNCTION` instruction accepts tuple of strings as annotations instead of dictionary. (Contributed by Yurii Karabas and Inada Naoki in [bpo-42202](#))

11 Build Changes

- The C99 functions `sprintf()` and `vsprintf()` are now required to build Python. (Contributed by Victor Stinner in [bpo-36020](#).)
- `sqlite3` requires SQLite 3.7.3 or higher. (Contributed by Sergey Fedoseev and Erlend E. Aasland [bpo-40744](#).)
- The `atexit` module must now always be built as a built-in module. (Contributed by Victor Stinner in [bpo-42639](#).)
- Added `--disable-test-modules` option to the `configure` script: don't build nor install test modules. (Contributed by Xavier de Gaye, Thomas Petazzoni and Peixing Xin in [bpo-27640](#).)

12 C API Changes

12.1 New Features

- The result of `PyNumber_Index()` now always has exact type `int`. Previously, the result could have been an instance of a subclass of `int`. (Contributed by Serhiy Storchaka in [bpo-40792](#).)
- Add a new `orig_argv` member to the `PyConfig` structure: the list of the original command line arguments passed to the Python executable. (Contributed by Victor Stinner in [bpo-23427](#).)
- The `PyDateTime_DATE_GET_TZINFO()` and `PyDateTime_TIME_GET_TZINFO()` macros have been added for accessing the `tzinfo` attributes of `datetime.datetime` and `datetime.time` objects. (Contributed by Zackery Spytz in [bpo-30155](#).)
- Add a `PyCodec_Unregister()` function to unregister a codec search function. (Contributed by Hai Shi in [bpo-41842](#).)
- The `PyIter_Send()` function was added to allow sending value into iterator without raising `StopIteration` exception. (Contributed by Vladimir Matveev in [bpo-41756](#).)
- Added `PyUnicode_AsUTF8AndSize()` to the limited C API. (Contributed by Alex Gaynor in [bpo-41784](#).)
- Added `PyModule_AddObjectRef()` function: similar to `PyModule_AddObject()` but don't steal a reference to the value on success. (Contributed by Victor Stinner in [bpo-1635741](#).)
- Added `Py_NewRef()` and `Py_XNewRef()` functions to increment the reference count of an object and return the object. (Contributed by Victor Stinner in [bpo-42262](#).)
- The `PyType_FromSpecWithBases()` and `PyType_FromModuleAndSpec()` functions now accept a single class as the *bases* argument. (Contributed by Serhiy Storchaka in [bpo-42423](#).)
- The `PyType_FromModuleAndSpec()` function now accepts `NULL tp_doc` slot. (Contributed by Hai Shi in [bpo-41832](#).)
- The `PyType_GetSlot()` function can accept static types. (Contributed by Hai Shi and Petr Viktorin in [bpo-41073](#).)

12.2 Porting to Python 3.10

- The `PY_SSIZE_T_CLEAN` macro must now be defined to use `PyArg_ParseTuple()` and `Py_BuildValue()` formats which use `#`: `es#`, `et#`, `s#`, `u#`, `y#`, `z#`, `U#` and `Z#`. See Parsing arguments and building values and the [PEP 353](#). (Contributed by Victor Stinner in [bpo-40943](#).)
- Since `Py_REFCNT()` is changed to the inline static function, `Py_REFCNT(obj) = new_refcnt` must be replaced with `Py_SET_REFCNT(obj, new_refcnt)`: see `Py_SET_REFCNT()` (available since Python 3.9). For backward compatibility, this macro can be used:

```
#if PY_VERSION_HEX < 0x030900A4
# define Py_SET_REFCNT(obj, refcnt) ((Py_REFCNT(obj) = (refcnt)), (void)0)
#endif
```

(Contributed by Victor Stinner in [bpo-39573](#).)

- Calling `PyDict_GetItem()` without GIL held had been allowed for historical reason. It is no longer allowed. (Contributed by Victor Stinner in [bpo-40839](#).)
- `PyUnicode_FromUnicode(NULL, size)` and `PyUnicode_FromStringAndSize(NULL, size)` raise `DeprecationWarning` now. Use `PyUnicode_New()` to allocate Unicode object without initial data. (Contributed by Inada Naoki in [bpo-36346](#).)
- The private `_PyUnicode_Name_CAPI` structure of the PyCapsule API `unicodedata.ucnhash_CAPI` has been moved to the internal C API. (Contributed by Victor Stinner in [bpo-42157](#).)
- `Py_GetPath()`, `Py_GetPrefix()`, `Py_GetExecPrefix()`, `Py_GetProgramFullPath()`, `Py_GetPythonHome()` and `Py_GetProgramName()` functions now return `NULL` if called before `Py_Initialize()` (before Python is initialized). Use the new Python Initialization Configuration API to get the Python Path Configuration.. (Contributed by Victor Stinner in [bpo-42260](#).)
- `PyList_SET_ITEM()`, `PyTuple_SET_ITEM()` and `PyCell_SET()` macros can no longer be used as l-value or r-value. For example, `x = PyList_SET_ITEM(a, b, c)` and `PyList_SET_ITEM(a, b, c) = x` now fail with a compiler error. It prevents bugs like `if (PyList_SET_ITEM(a, b, c) < 0) ... test`. (Contributed by Zackery Spytz and Victor Stinner in [bpo-30459](#).)

12.3 Deprecated

- The `PyUnicode_InternImmortal()` function is now deprecated and will be removed in Python 3.12: use `PyUnicode_InternInPlace()` instead. (Contributed by Victor Stinner in [bpo-41692](#).)

12.4 Removed

- `PyObject_AsCharBuffer()`, `PyObject_AsReadBuffer()`, `PyObject_CheckReadBuffer()`, and `PyObject_AsWriteBuffer()` are removed. Please migrate to new buffer protocol; `PyObject_GetBuffer()` and `PyBuffer_Release()`. (Contributed by Inada Naoki in [bpo-41103](#).)
- Removed `Py_UNICODE_str*` functions manipulating `Py_UNICODE*` strings. (Contributed by Inada Naoki in [bpo-41123](#).)
 - `Py_UNICODE_strlen`: use `PyUnicode_GetLength()` or `PyUnicode_GET_LENGTH`
 - `Py_UNICODE_strcat`: use `PyUnicode_CopyCharacters()` or `PyUnicode_FromFormat()`
 - `Py_UNICODE_strcpy`, `Py_UNICODE_strncpy`: use `PyUnicode_CopyCharacters()` or `PyUnicode_Substring()`
 - `Py_UNICODE_strcmp`: use `PyUnicode_Compare()`
 - `Py_UNICODE_strncmp`: use `PyUnicode_Tailmatch()`

- `Py_UNICODE_strchr`, `Py_UNICODE_strchr`: use `PyUnicode_FindChar()`
- Removed `PyUnicode_GetMax()`. Please migrate to new **(PEP 393)** APIs. (Contributed by Inada Naoki in [bpo-41103](#).)
- Removed `PyLong_FromUnicode()`. Please migrate to `PyLong_FromUnicodeObject()`. (Contributed by Inada Naoki in [bpo-41103](#).)
- Removed `PyUnicode_AsUnicodeCopy()`. Please use `PyUnicode_AsUCS4Copy()` or `PyUnicode_AsWideCharString()` (Contributed by Inada Naoki in [bpo-41103](#).)
- Removed `_Py_CheckRecursionLimit` variable: it has been replaced by `ceval.recursion_limit` of the `PyInterpreterState` structure. (Contributed by Victor Stinner in [bpo-41834](#).)
- Removed undocumented macros `Py_ALLOW_RECURSION` and `Py_END_ALLOW_RECURSION` and the `recursion_critical` field of the `PyInterpreterState` structure. (Contributed by Serhiy Storchaka in [bpo-41936](#).)
- Removed the undocumented `PyOS_InitInterrupts()` function. Initializing Python already implicitly installs signal handlers: see `PyConfig.install_signal_handlers`. (Contributed by Victor Stinner in [bpo-41713](#).)

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