Projection: Getting only what you need

INTRODUCTION TO MONGODB IN PYTHON

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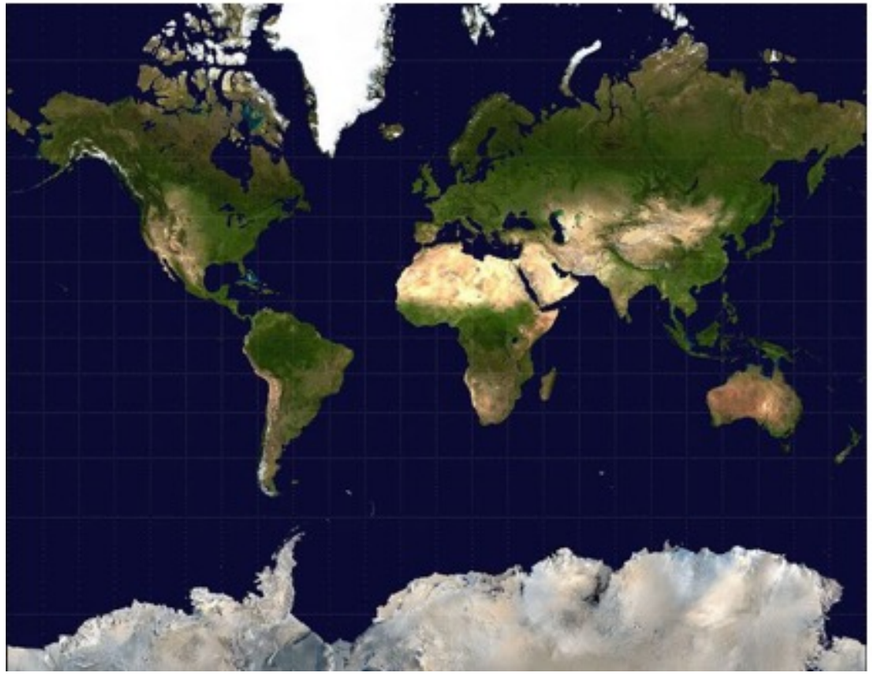
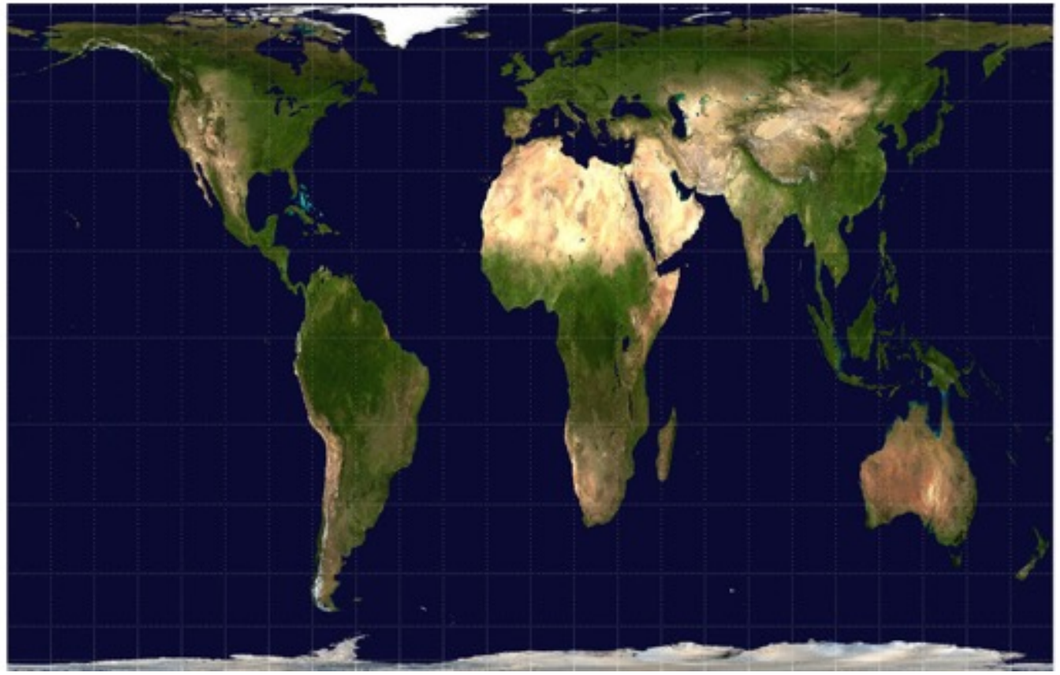
What is "projection"?

- reducing data to fewer dimensions
- asking certain data to "speak up"!

Mercator projection



Gall-Peters projection



Projection in MongoDB

```
# include only prizes.affiliations
# exclude _id
docs = db.laureates.find(
         filter={},
         projection={"prizes.affiliations": 1,
                     "_id": 0})
type(docs)
```

```
<pymongo.cursor.Cursor at 0x10d6e69e8>
```

Projection as a dictionary:

- Include fields: `"field_name" : 1`
- `"_id"` is included by default

Projection in MongoDB

```
# include only prizes.affiliations
# exclude _id
docs = db.laureates.find(
         filter={},
         projection={"prizes.affiliations": 1,
                     "_id": 0})
type(docs)
```

```
<pymongo.cursor.Cursor at 0x10d6e69e8>
```

```
# convert to list and slice
list(docs)[:3]
```

```
[{'prizes': [{'affiliations': [{'city': 'Munich',
      'country': 'Germany',
      'name': 'Munich University'}]}]},
 {'prizes': [{'affiliations': [{'city': 'Leiden',
      'country': 'the Netherlands',
      'name': 'Leiden University'}]}]},
 {'prizes': [{'affiliations': [{'city': 'Amsterdam',
      'country': 'the Netherlands',
      'name': 'Amsterdam University'}]}]}]
```

Missing fields

```
# use "gender":"org" to select organizations
# organizations have no bornCountry
docs = db.laureates.find(
         filter={"gender": "org"},
         projection=["bornCountry", "firstname"])
list(docs)
```

```
[{'_id': ObjectId('5bc56154f35b634065ba1dff'),
  'firstname': 'United Nations Peacekeeping Forces'},
 {'_id': ObjectId('5bc56154f35b634065ba1df3'),
  'firstname': 'Amnesty International'},
  ...
]
```

Projection as a list

- list the fields to include `["field_name1", "field_name2"]`
- `"_id"` is included by default

Missing fields

```
# use "gender":"org" to select organizations
# organizations have no bornCountry
docs = db.laureates.find(
         filter={"gender": "org"},
         projection=["bornCountry", "firstname"])
list(docs)
```

```
[{'_id': ObjectId('5bc56154f35b634065ba1dff'),
  'firstname': 'United Nations Peacekeeping Forces'},
 {'_id': ObjectId('5bc56154f35b634065ba1df3'),
  'firstname': 'Amnesty International'},
  ...
]
```

- only projected fields that *exist* are returned

```
docs = db.laureates.find({}, ["favoriteIceCreamFlavor"])
list(docs)
```

```
[{'_id': ObjectId('5bc56154f35b634065ba1dff')},
 {'_id': ObjectId('5bc56154f35b634065ba1df3')},
 {'_id': ObjectId('5bc56154f35b634065ba1db1')},
 ...
]
```

Simple aggregation

```
docs = db.laureates.find({}, ["prizes"])

n_prizes = 0
for doc in docs:
    # count the number of pizes in each doc
    n_prizes += len(doc["prizes"])
print(n_prizes)
```

```
941
```

```
# using comprehension
sum([len(doc["prizes"]) for doc in docs])
```

```
941
```

Let's project!

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Sorting

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Sorting post-query with Python

```
docs = list(db.prizes.find({"category": "physics"}, ["year"]))

print([doc["year"] for doc in docs][:5])
```

```
['2018', '2017', '2016', '2015', '2014']
```

```
from operator import itemgetter

docs = sorted(docs, key=itemgetter("year"))
print([doc["year"] for doc in docs][:5])
```

```
['1901', '1902', '1903', '1904', '1905']
```

```
docs = sorted(docs, key=itemgetter("year"), reverse=True)
print([doc["year"] for doc in docs][:5])
```

```
['2018', '2017', '2016', '2015', '2014']
```

Sorting in-query with MongoDB

```
cursor = db.prizes.find({"category": "physics"}, ["year"],
                        sort=[("year", 1)])
print([doc["year"] for doc in cursor][:5])
```

```
['1901', '1902', '1903', '1904', '1905']
```

```
cursor = db.prizes.find({"category": "physics"}, ["year"],
                        sort=[("year", -1)])
print([doc["year"] for doc in cursor][:5])
```

```
['2018', '2017', '2016', '2015', '2014']
```


```
['2018', '2017', '2016', '2015', '2014']
```

Primary and secondary sorting

```
for doc in db.prizes.find(
        {"year": {"$gt": "1966", "$lt": "1970"}},
        ["category", "year"],
        sort=[("year", 1), ("category", -1)]):
    print("{year} {category}".format(**doc))
```

```
1967 physics
1967 medicine
1967 literature
1967 chemistry
1968 physics
1968 peace
1968 medicine
1968 literature
1968 chemistry
1969 physics
1969 peace
1969 medicine
1969 literature
1969 economics
1969 chemistry
```

Sorting with pymongo versus MongoDB shell

In MongoDB shell:

- Example `sort` argument: `{"year": 1, "category": -1}`
- JavaScript objects retain key order as entered

In Python (< 3.7):

```
{"year": 1, "category": 1}
```

```
{'category': 1, 'year': 1}
```

```
[("year", 1), ("category", 1)]
```

```
[('year', 1), ('category', 1)]
```

Let's get sorted!

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What are indexes?

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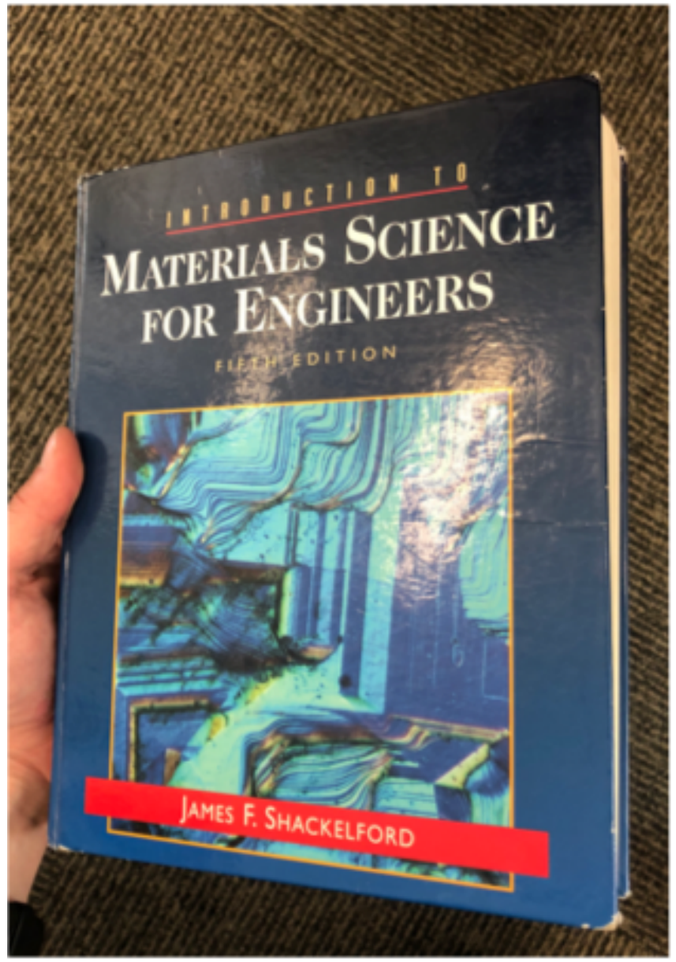
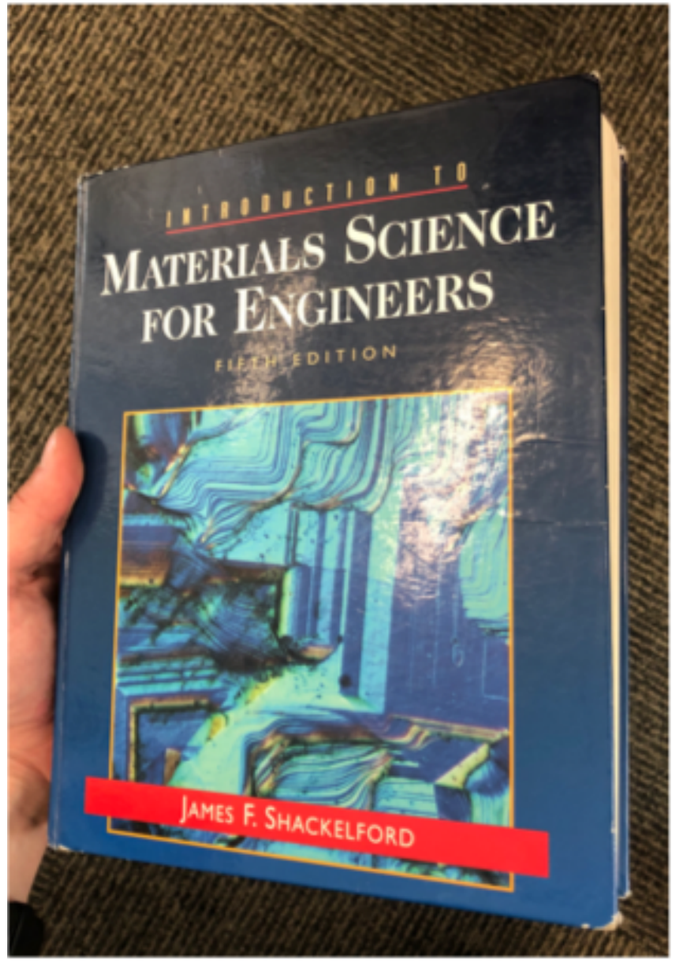
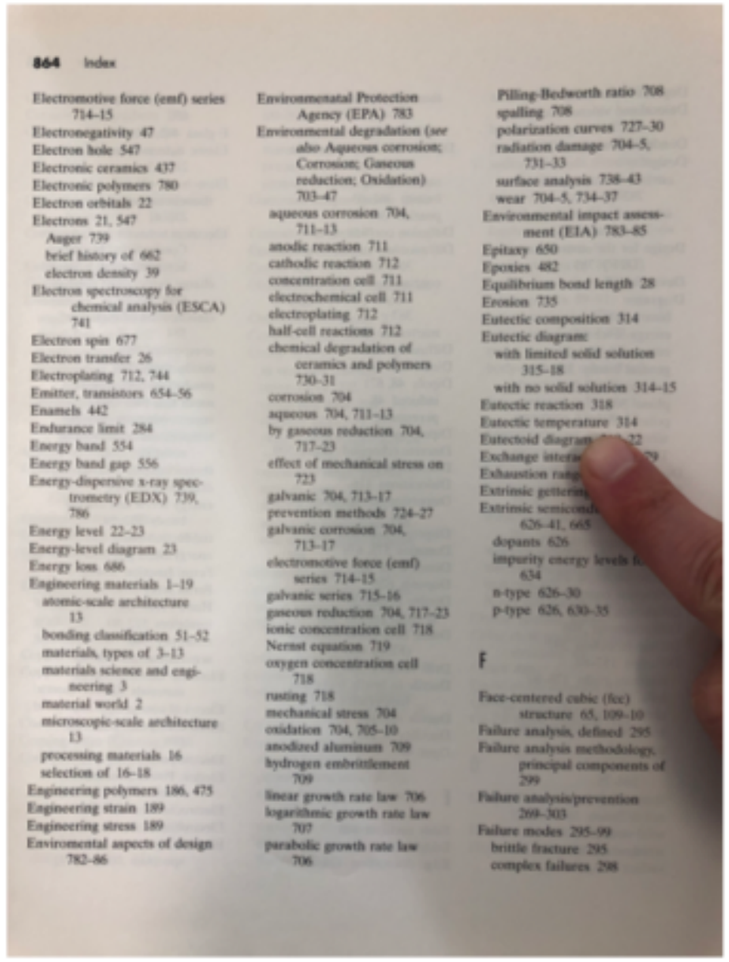
What are indexes?

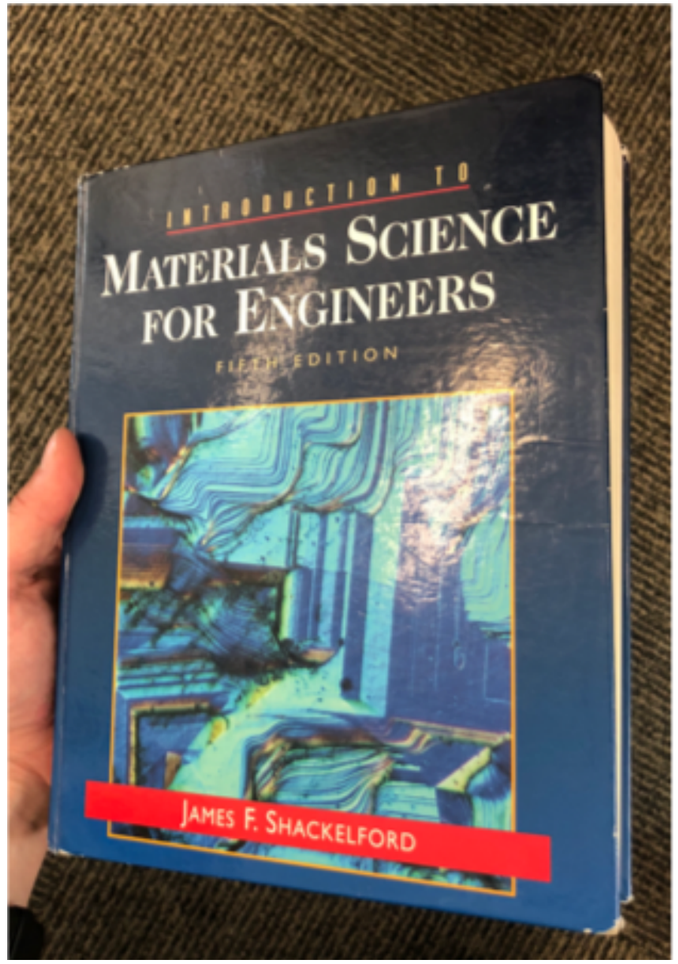


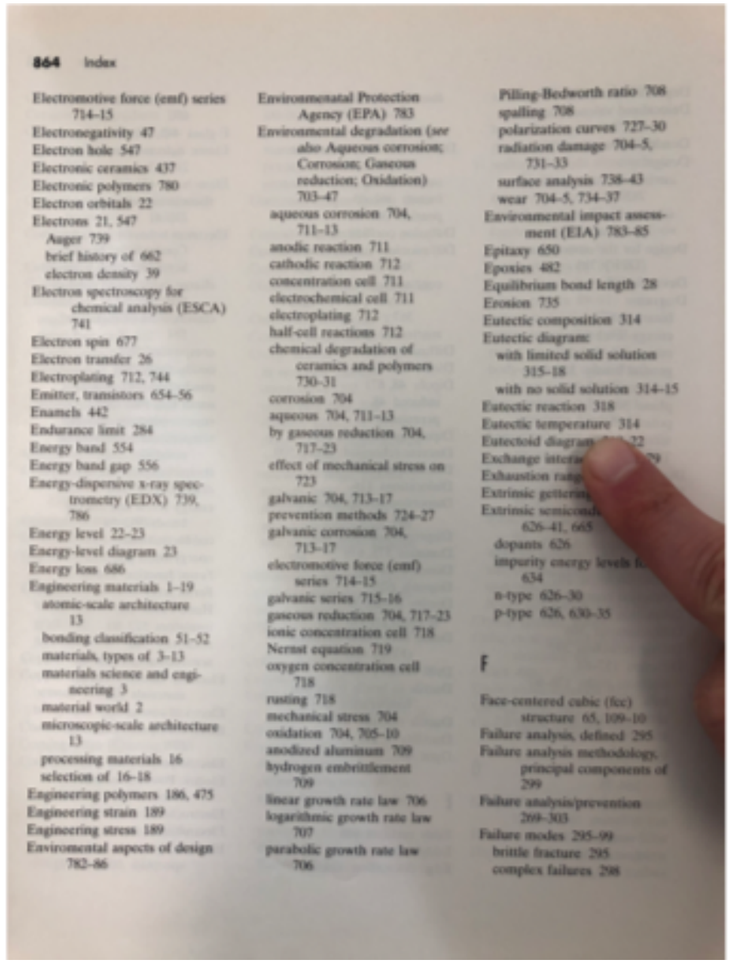
What are indexes?





What are indexes?





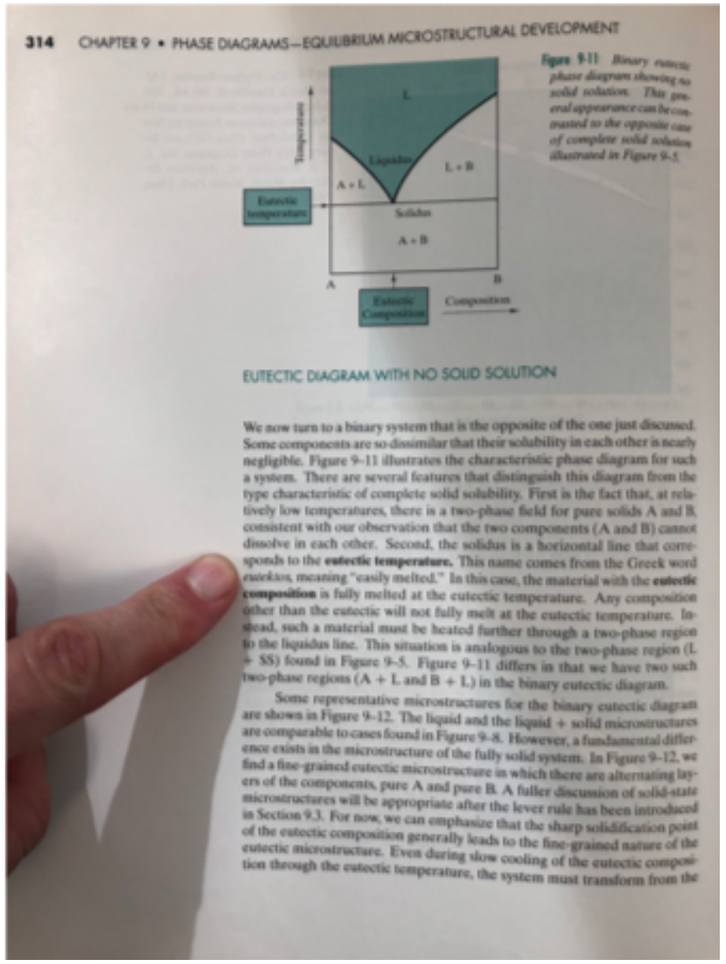


Figure 9-11 Binary eutectic phase diagram showing no solid solution. This general appearance can be contrasted to the opposite case of complete solid solution illustrated in Figure 9-5.

EUTECTIC DIAGRAM WITH NO SOLID SOLUTION

We now turn to a binary system that is the opposite of the one just discussed. Some components are so dissimilar that their solubility in each other is nearly negligible. Figure 9–11 illustrates the characteristic phase diagram for such a system. There are several features that distinguish this diagram from the type characteristic of complete solid solubility. First is the fact that, at relatively low temperatures, there is a two-phase field for pure solids A and B, consistent with our observation that the two components (A and B) cannot dissolve in each other. Second, the solidus is a horizontal line that corresponds to the **eutectic temperature.** This name comes from the Greek word *eutektos,* meaning "easily melted." In this case, the material with the **eutectic composition** is fully melted at the eutectic temperature. Any composition other than the eutectic will not fully melt at the eutectic temperature. Instead, such a material must be heated further through a two-phase region to the liquidus line. This situation is analogous to the two-phase region (L + SS) found in Figure 9–5. Figure 9–11 differs in that we have two such two-phase regions (A + L and B + L) in the binary eutectic diagram.

Some representative microstructures for the binary eutectic diagram are shown in Figure 9–12. The liquid and the liquid + solid microstructures are comparable to cases found in Figure 9–8. However, a fundamental difference exists in the microstructure of the fully solid system. In Figure 9–12, we find a fine-grained eutectic microstructure in which there are alternating layers of the components, pure A and pure B. A fuller discussion of solid-state microstructures will be appropriate after the lever rule has been introduced in Section 9.3. For now, we can emphasize that the sharp solidification point of the eutectic composition generally leads to the fine-grained nature of the eutectic microstructure. Even during slow cooling of the eutectic composition through the eutectic temperature, the system must transform from the

When to use indexes?

- Queries with high specificity
- Large documents
- Large collections

Gauging performance before indexing

Jupyter Notebook `%%timeit` magic (same as `python -m timeit "[expression]"`)

```
%%timeit
docs = list(db.prizes.find({"year": "1901"}))
```

```
524 µs ± 7.34 µs per loop (mean ± std. dev. of 7 runs, 1000 loops each)
```

```
%%timeit
docs = list(db.prizes.find({}, sort=[("year", 1)]))
```

```
5.18 ms ± 54.9 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

Adding a single-field index

- index model: list of `(field, direction)` pairs.
- directions: 1 (ascending) and -1 (descending)

```
db.prizes.create_index([("year", 1)])
```

```
'year_1'
```

```
%%timeit
# Previously: 524 µs ± 7.34 µs
docs = list(db.prizes.find({"year": "1901"}))
```

```
379 µs ± 1.62 µs per loop
(mean ± std. dev. of 7 runs, 1000 loops each)
```

```
%%timeit
# Previously: 5.18 ms ± 54.9 µs
docs = list(db.prizes.find({}, sort=[("year", 1)]))
```

```
4.28 ms ± 95.7 µs per loop
(mean ± std. dev. of 7 runs, 100 loops each)
```

```
4.28 ms ± 95.7 µs per loop (mean ± std. dev. of 7 runs, 10
```

Adding a compound (multiple-field) index

```
db.prizes.create_index([("category", 1), ("year", 1)])
```

- index "covering" a query with projection

```
list(db.prizes.find({"category": "economics"},
                    {"year": 1, "_id": 0}))
```

```
# Before
645 µs ± 3.87 µs per loop
(mean ± std. dev. of 7 runs, 1000 loops each)
# After
503 µs ± 4.37 µs per loop
(mean ± std. dev. of 7 runs, 1000 loops each)
```

- index "covering" a query with projection and sorting

```
db.prizes.find_one({"category": "economics"},
                   {"year": 1, "_id": 0},
                   sort=[("year", 1)])
```

```
# Before
673 µs ± 3.36 µs per loop
(mean ± std. dev. of 7 runs, 1000 loops each)
# After
407 µs ± 5.51 µs per loop
(mean ± std. dev. of 7 runs, 1000 loops each)
```

Learn more: ask your collection and your queries

```
db.laureates.index_information() # always an index on "_id" field
```

```
{'_id_': {'v': 2, 'key': [('_id', 1)], 'ns': 'nobel.laureates'}}
```

```
db.laureates.find(
    {"firstname": "Marie"}, {"bornCountry": 1, "_id": 0}).explain()
```

```
...
'winningPlan': {'stage': 'PROJECTION',
   'transformBy': {'bornCountry': 1, '_id': 0},
   'inputStage': {'stage': 'COLLSCAN',
...
```

```
db.laureates.create_index([("firstname", 1), ("bornCountry", 1)])
db.laureates.find(
    {"firstname": "Marie"}, {"bornCountry": 1, "_id": 0}).explain()
```

```
...
'winningPlan': {'stage': 'PROJECTION',
   'transformBy': {'bornCountry': 1, '_id': 0},
   'inputStage': {'stage': 'IXSCAN',
    'keyPattern': {'firstname': 1, 'bornCountry': 1},
    'indexName': 'firstname_1_bornCountry_1',
...
```

Let's practice!

INTRODUCTION TO MONGODB IN PYTHON

Limits and Skips with Sorts, Oh My!

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Limiting our exploration

```
for doc in db.prizes.find({}, ["laureates.share"]):
    share_is_three = [laureate["share"] == "3"
                      for laureate in doc["laureates"]]
    assert all(share_is_three) or not any(share_is_three)
```

```
for doc in db.prizes.find({"laureates.share": "3"}):
    print("{year} {category}".format(**doc))
```

```
2017 chemistry
2017 medicine
2016 chemistry
2015 chemistry
2014 physics
2014 chemistry
2013 chemistry
...
```

```
for doc in db.prizes.find({"laureates.share": "3"}, limit=3):
    print("{year} {category}".format(**doc))
```

```
2017 chemistry
2017 medicine
2016 chemistry
```

Skips and paging through results

```
for doc in db.prizes.find({"laureates.share": "3"}, limit=3):
    print("{year} {category}".format(**doc))
```

```
2017 chemistry
2017 medicine
2016 chemistry
```

```
for doc in db.prizes.find({"laureates.share": "3"}, skip=3, limit=3):
    print("{year} {category}".format(**doc))
```

```
2015 chemistry
2014 physics
2014 chemistry
```

```
for doc in db.prizes.find({"laureates.share": "3"}, skip=6, limit=3):
    print("{year} {category}".format(**doc))
```

```
2013 chemistry
2013 medicine
2013 economics
```

Using cursor methods for {sort, skip, limit}

```
for doc in db.prizes.find({"laureates.share": "3"}).limit(3):
    print("{year} {category}".format(**doc))
```

```
2017 chemistry
2017 medicine
2016 chemistry
```

```
for doc in (db.prizes.find({"laureates.share": "3"}).skip(3).limit(3)):
    print("{year} {category}".format(**doc))
```

```
2015 chemistry
2014 physics
2014 chemistry
```

```
for doc in (db.prizes.find({"laureates.share": "3"})
            .sort([("year", 1)])
            .skip(3)
            .limit(3)):
    print("{year} {category}".format(**doc))
```

```
1954 medicine
1956 physics
1956 medicine
```

Simpler sorts of sort

```
cursor1 = (db.prizes.find({"laureates.share": "3"}).skip(3).limit(3)
          .sort([("year", 1)]))
```

```
cursor2 = (db.prizes.find({"laureates.share": "3"}).skip(3).limit(3)
          .sort("year", 1))
```

```
cursor3 = (db.prizes.find({"laureates.share": "3"}).skip(3).limit(3)
          .sort("year"))
```

```
docs = list(cursor1)
assert docs == list(cursor2) == list(cursor3)
for doc in docs:
    print("{year} {category}".format(**doc))
```

```
1954 medicine
1956 physics
1956 medicine
```

```
doc = db.prizes.find_one({"laureates.share": "3"},
                         skip=3, sort=[("year", 1)])
print("{year} {category}".format(**doc))
```

Limit or Skip Practice? Exactly.

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