The RDKit and PostgreSQL: an open-source database system for chemistry

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5th Meeting on U.S. Government Chemical Databases and Open Chemistry
August 2011
Acknowledgements

- **Novartis:**
  - Tom Digby (Legal)
  - John Davies (CPC/LFP)
  - Eddie Cao (NIBR IT)
  - Richard Lewis (GDC/CADD)
  - Nikolaus Stiefl (GDC/CADD)
  - Peter Gedeck (GDC/CADD)

- **Rational Discovery:**
  - Santosh Putta (currently at Nodality)
  - Julie Penzotti

- **RDKit open-source community**

- **postgresql cartridge:**
  - Michael Stonebraker
  - Oleg Bartunov
  - Teodor Sigaev
  - Pavel Velikhov

- **Entagen (SWIG wrappers):**
  - Chris Bouton
  - Erik Bakke
  - James Hardwick

- **knime.com**
  - Michael Berthold
  - Thorsten Meinl
  - Bernd Wiswedel
Overview

- **RDKit: what is it?**

- RDKit + Knime

- RDKit + PostgreSQL

- Case study: matched pairs analysis
Cheminformatics toolkits

Timeline of cheminformatics toolkits

Source: Andrew Dalke
**RDKit: What is it?**

- **Python (2.x), Java, and C++ toolkit for cheminformatics**
  - Core data structures and algorithms in C++, including heavy use of Boost
  - Python wrapper generated using Boost.Python
  - Java wrapper generated with SWIG

- **Functionality:**
  - 2D and 3D molecular operations
  - Descriptor generation for machine learning
  - Molecular database cartridge
  - Knime nodes
  - Supports Mac/Windows/Linux

- **History:**
  - 2000-2006: Developed and used at Rational Discovery for building predictive models for ADME, Tox, biological activity
  - June 2006: Open-source (BSD license) release of software, Rational Discovery shuts down
  - To present: Open-source development continues, use within Novartis, contributions from Novartis back to open-source version
What is this all about?

Exact same algorithms/implmentations accessible from many different endpoints
RDKit: Where is it?

- Web page: http://www.rdkit.org
- Sourceforge: svn repository, bug tracker, mailing lists, downloads
  - http://sourceforge.net/projects/rdkit
- Google code: wiki, downloads
  - http://code.google.com/p/rdkit/
- Releases: quarterly (more or less)
- Licensing: new BSD
- Documentation:
  - HTML/PDF “Getting Started” documentation
  - in-code docs extracted by either doxygen (C++) or epydoc (python)
- Getting help:
  - Check the wiki and “Getting Started” document
  - The rdkit-discuss mailing list
The new documentation:

Built using Python’s standard docs tool: Sphinx
Sample section from introductory docs:

Reading and Writing Molecules

Reading single molecules
The majority of the basic molecular functionality is found in module `rdkit.Chem`:

```python
>>> from rdkit import Chem
```

Individual molecules can be constructed using a variety of approaches:

```python
>>> m = Chem.MolFromSmiles('Cc1ccccc1')
>>> m = Chem.MolFromMolFile('data/input.mol')
>>> stringWithMolData=file('data/input.mol','r').read()
>>> m = Chem.MolFromMolBlock(stringWithMolData)
```

All of these functions return a `Mol` object on success:

```python
>>> m
<rdkit.Chem.rdchem.Mol object at 0x...>
```

Note: docs that include python code snippets are tested.
RDKit: Documentation?

The wiki: http://code.google.com/p/rdkit/w/list
RDKit: Who is using it?

- Hard to say with any certainty
- ~300 downloads of each new version
- Active contributors to the mailing list from:
  - Big pharma
  - Small pharma/biotech
  - Software/Services
  - Academia
- Starting to see contributions coming from the community (wiki pages, code patches, changes to the build system, etc.) as well as active use in other systems.
Things you should know

- Molecules should be “correct”: i.e. there should be a valid Lewis-dot structure. If not, they will be rejected:

  >>> Chem.MolFromSmiles('CC(F)(Cl)(Br)I')
  [08:58:09] Explicit valence for atom # 1 C, 5, is greater than permitted

- The software generally doesn’t try and read the user’s mind

  **Nitro groups and N-oxides are repaired:**

  >>> Chem.CanonSmiles('CN(=O)=O')
  'C[N+](=O)[O-]'

  >>> Chem.CanonSmiles('c1ccccc1=O')
  '[O-][n+]ccccccc1'

  **but some odd constructs (this one from ChEMBL SMILES) are not:**

  >>> Chem.MolFromSmiles('CN=N#N')
  [16:30:08] Explicit valence for atom # 2 N, 5, is greater than permitted
  ... snip ...

  >>> Chem.CanonSmiles('CN=[N+]=[N-]')
  'CN=[N+]=[N-]'
What can you do with it?

A laundry list

- Input/Output: SMILES/SMARTS, SDF, TDT, SLN\(^1\), Corina \text{mol2}\(^1\), InChI\(^2\)
- “Cheminformatics”:
  - Substructure searching
  - Canonical SMILES
  - Chirality support (i.e. R/S or E/Z labeling)
  - Chemical transformations (e.g. remove matching substructures)
  - Chemical reactions
  - Molecular serialization (e.g. mol <-> text)
- 2D depiction, including constrained depiction
- 2D->3D conversion/conformational analysis via distance geometry
- UFF implementation for cleaning up structures
- Fingerprinting:
  - Daylight-like, atom pairs, topological torsions, Morgan algorithm, “MACCS keys”, etc.
- Similarity/diversity picking
- 2D pharmacophores\(^1\)
- Gasteiger-Marsili charges
- Murcko analysis
- Hierarchical subgraph/fragment analysis
- RECAP and BRICS implementations

\(^1\) functional, but not great implementations

\(^2\) Solid output, experimental input
What can you do with it?
A laundry list, cntd

- Feature maps
- Shape-based similarity
- Molecule-molecule alignment
- Shape-based alignment (subshape alignment) \(^1\)
- Integration with PyMOL for 3D visualization
- Database integration
- Molecular descriptor library:
  - Topological (\(\kappa 3\), Balaban J, etc.)
  - Electrotopological state (Estate)
  - clogP, MR (Wildman and Crippen approach)
  - “MOE like” VSA descriptors
  - Feature-map vectors
- Machine Learning:
  - Clustering (hierarchical)
  - Information theory (Shannon entropy, information gain, etc.)
  - Decision trees, naïve Bayes\(^1\), kNN\(^1\)
  - Bagging, random forests
  - Infrastructure (data splitting, shuffling, enrichment plots, serializable models, etc.)

\(^1\) functional, but not great implementations
Overview

- RDKit: what is it?
- RDKit + Knime
- RDKit + PostgreSQL
- Case study: matched pairs analysis
Knime integration

- Out of the box Knime is strong on data processing and mining, weak on chemistry.
- Goal: develop a set of open-source RDKit-based nodes for Knime that provide basic cheminformatics functionality
- Distributed from knime community site
- Binaries available as an update site (no RDKit build/installation required)
- Work in progress: more nodes being added

Note: We’ll be developing more open-source nodes at the Knime open-source days in October: http://www.knime.org/kos-2011

1 Work done together with knime.com
Overview

- RDKit: what is it?
- RDKit + Knime
- RDKit + PostgreSQL
- Case study: matched pairs analysis
The database cartridge

- Integration of RDKit fingerprinting and substructure search functionality with PostgreSQL
- Bit-vector and counts-based fingerprints along with common similarity metrics (Tanimoto and Dice) integrated with PostgreSQL indexing system to allow fast searches (~1 million compounds/sec on a single CPU)
- Available similarity fingerprints:
  - Morgan (ECFP-like), available as bit vectors or counts
  - FeatMorgan (FCFP-like), available as bit vectors or counts
  - RDKit (Daylight-like), available as bit vectors
  - atom pairs, available as bit vectors or counts
  - topological torsions, available as bit vectors or counts
- SMILES- and SMARTS-based substructure querying integrated with indexing system
- Standard Lipinski-like descriptors (logp, tpsa, MW, etc.)
- Part of the RDKit open-source distribution since July 2010
Cartridge performance #1

- Database: 100K diverse drug-like molecules from ZINC
  - Molecules load/index time: 109 sec / 343 sec
  - Fingerprints (Morgan2) calculation/index time: 23.1 sec / 9.3 sec
- "Fragments" queries: 500 diverse fragment-like molecules from ZINC
- "Leads" queries: 500 diverse lead-like molecules from ZINC
- Hardware: MacBook Pro (2.5GHz Core2 Duo)
- Do queries via a cross join (i.e. 500 queries x 100K database molecules = 50M possible comparisons/searches)
- Results:

<table>
<thead>
<tr>
<th>Query Set</th>
<th>SSS</th>
<th>Similarity (0.8)</th>
<th>Similarity (0.6)</th>
<th>Similarity (0.5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc Fragments</td>
<td>23.3</td>
<td>14.6</td>
<td>36.4</td>
<td>37.1</td>
</tr>
<tr>
<td>Zinc Leads</td>
<td>8.2</td>
<td>14.8</td>
<td>36.2</td>
<td>38.5</td>
</tr>
</tbody>
</table>
Cartridge performance #2

- Database: 5 million molecules from the emolecules catalog
  - Molecules load/index time: 4040 sec / 7832 sec
- Hardware: Dell Studio XPS (2.9GHz i7 with 8GB of RAM, Ubuntu Linux)

### Similarity queries:
- Zinc lead-like set: queries return 0-50 hits in 5-8 seconds

<table>
<thead>
<tr>
<th>SSS Query</th>
<th>Count</th>
<th>Run time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>c1cccc2c1nncc2</td>
<td>996</td>
<td>2.4</td>
</tr>
<tr>
<td>c1ccnc2c1nccn2</td>
<td>1366</td>
<td>0.8</td>
</tr>
<tr>
<td>c1cncc2n1ccn2</td>
<td>523</td>
<td>2.3</td>
</tr>
<tr>
<td>Nc1ncnc(N)n1</td>
<td>14227</td>
<td>3.8</td>
</tr>
<tr>
<td>c1scnn1</td>
<td>88564</td>
<td>31.6</td>
</tr>
<tr>
<td>c1cccc2c1ncs2</td>
<td>95288</td>
<td>55.3</td>
</tr>
</tbody>
</table>

- Performance here is a function of the SSS fingerprint quality
- SMARTS-based queries can be considerably slower
- Getting first 50 results from any of these queries: <0.5 sec
The database cartridge

- How hard is it to add something new?
  1. Write C++ function implementing new functionality (probably not cartridge specific, could also be used from Python or Java)
  2. Add one boilerplate C++ function to cartridge code exposing that function
  3. Add one boilerplate C function to cartridge code
  4. Add one boilerplate SQL function to cartridge code
  5. Add tests

- The first step is the hardest part (unless the function already exists), the rest takes 5-10 minutes.

- Reference/HowTo for this:
  http://www.mail-archive.com/rdkit-discuss@lists.sourceforge.net/msg01549.html
Using the database cartridge

**Similarity search with Morgan fingerprint:**

```sql
dvendors=# select id, tanimoto_sml(morganbv_fp('N=C1OC2=C(C=CC=C2)C=C1', 2), mfp2)
  from fps where morganbv_fp('N=C1OC2=C(C=CC=C2)C=C1', 2) % mfp2;
```

<table>
<thead>
<tr>
<th>id</th>
<th>tanimoto_sml</th>
</tr>
</thead>
<tbody>
<tr>
<td>9171448</td>
<td>0.538461538461538</td>
</tr>
<tr>
<td>765434</td>
<td>0.538461538461538</td>
</tr>
</tbody>
</table>

(2 rows)

**Substructure Search:**

```sql
dvendors=# select count(*) from mols where m@>'N=C1OC2=C(C=CC=C2)C=C1';
```

<table>
<thead>
<tr>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>2854</td>
</tr>
</tbody>
</table>

(1 row)

**Properties:**

```sql
dvendors=# select mol_tpsa('C1CCC1CC(=O)O':mol) tpsa, mol_logp('C1CCC1CC(=O)O':mol) clogp;
```

<table>
<thead>
<tr>
<th>tpsa</th>
<th>clogp</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.3</td>
<td>1.2612</td>
</tr>
</tbody>
</table>

(1 row)
Overview

- RDKit: what is it?
- RDKit + Knime
- RDKit + PostgreSQL
- Case study: matched pairs analysis
Case Study: bringing the pieces together

- Combine the RDKit + the PostgreSQL cartridge + Knime to do matched-pairs analysis
- Idea: find pairs of molecules that are structurally similar but that have quite different activities to identify interesting/useful transformations.
- Key concept is disparity: $\Delta \text{Activity} / (1-\text{similarity})$
- Easily done from Python using the RDKit, but it becomes time consuming as the number of molecules increases ($N^2$ similarity calculations required).
Atom-Pair and Topological-Torsion Fingerprints

related descriptors from the “distant” past

- Atom-type:
  (Element, #heavy neighbors, #pi electrons)

- Atom Pair\(^1\):
  Atom-type – topological distance – Atom-type

- Topological Torsion\(^2\):
  Atom-type – Atom-type – Atom-type – Atom-type

- Both fingerprints can use counts (not 1/0 values)

Using count-based fingerprints for matched pairs

```python
>>> DataStructs.TanimotoSimilarity(fp1a, fp1b)
0.8918918918918918
>>> DataStructs.TanimotoSimilarity(fp2a, fp2b)
0.8518518518518518
>>> DataStructs.TanimotoSimilarity(fp3a, fp3b)
0.8974358974358974

>>> f1 = fp1a-fp1b
>>> f2 = fp2a-fp2b
>>> f3 = fp3a-fp3b
>>> f1==f2
True
>>> f1==f3
True

```}

Fingerprint math: subtracting two fingerprints from another gives another fingerprint.
Using count-based fingerprints for matched pairs

```python
>>> for bit, v in f1.GetNonzeroElements().items():
.....:    print Torsions.ExplainPathScore(bit), v
.....:
    (('C', 1, 0), ('C', 3, 1), ('C', 2, 1), ('C', 2, 1)) 1
    (('C', 1, 0), ('C', 3, 1), ('C', 2, 1), ('C', 3, 1)) 1
    (('C', 3, 1), ('C', 2, 1), ('C', 3, 1), ('Cl', 1, 0)) -1
    (('C', 2, 1), ('C', 2, 1), ('C', 3, 1), ('Cl', 1, 0)) -1
```
### A standard molecular db schema

**Table "herg_data.mols"**

<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Modifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>integer</td>
<td>not null</td>
</tr>
<tr>
<td>compound_id</td>
<td>text</td>
<td></td>
</tr>
<tr>
<td>m</td>
<td>mol</td>
<td></td>
</tr>
</tbody>
</table>

Indexes:
- "mols_pkey" PRIMARY KEY, btree (id)
- "molidx" gist (m)

Triggers:
- `process_mol` AFTER INSERT OR DELETE OR UPDATE ON herg_data.mols FOR EACH ROW EXECUTE PROCEDURE herg_data.process_update_mol()

**Table "herg_data.countfps"**

<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Modifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>integer</td>
<td>not null</td>
</tr>
<tr>
<td>pairfp</td>
<td>sfp</td>
<td></td>
</tr>
<tr>
<td>torsionfp</td>
<td>sfp</td>
<td></td>
</tr>
<tr>
<td>mfp2</td>
<td>sfp</td>
<td></td>
</tr>
</tbody>
</table>

Indexes:
- "countfps_pkey" PRIMARY KEY, btree (id)
- "apfpcountidx" gist (pairfp sfp_low_ops)
- "mfpscountidx" gist (mfp2 sfp_low_ops)
- "torsionfpcountidx" gist (torsionfp sfp_low_ops)

**Table "herg_data.fps"**

<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Modifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>integer</td>
<td>not null</td>
</tr>
<tr>
<td>mfp2</td>
<td>bfp</td>
<td></td>
</tr>
<tr>
<td>ffp2</td>
<td>bfp</td>
<td></td>
</tr>
</tbody>
</table>

Indexes:
- "fps_pkey" PRIMARY KEY, btree (id)
- "ffp2idx" gist (ffp2)
- "mfp2idx" gist (mfp2)

**Table "herg_data.molvals"**

<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Modifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>integer</td>
<td>not null</td>
</tr>
<tr>
<td>mfp2</td>
<td>bfp</td>
<td></td>
</tr>
<tr>
<td>ffp2</td>
<td>bfp</td>
<td></td>
</tr>
</tbody>
</table>

Indexes:
- "molvals_pkey" PRIMARY KEY, btree (id)

**Table "herg_data.pairbvfps"**

<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Modifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>integer</td>
<td>not null</td>
</tr>
<tr>
<td>pairfp</td>
<td>bfp</td>
<td></td>
</tr>
<tr>
<td>torsionfp</td>
<td>bfp</td>
<td></td>
</tr>
</tbody>
</table>

Indexes:
- "pairbvfps_pkey" PRIMARY KEY, btree (id)
- "apfpbvidx" gist (pairfp)
- "torsionfpbvidx" gist (torsionfp)
select *, (pact1-pact2)/dist disparity, pact2-pact1 dact from
  (select ms1.id id1, ms1.m smiles1, ms2.id id2, ms2.m smiles2, dist,
   -1*log(vs1.ic50_nm*1e-9) pact1,
   -1*log(vs2.ic50_nm*1e-9) pact2
  from (select fp1.id id1, fp2.id id2,
      1.0-dice_sml(fp1.torsionfp, fp2.torsionfp) dist
      from cdk2.countfps as fp1
      cross join cdk2.countfps as fp2
      where fp1.torsionfp#fp2.torsionfp and fp1.id!=fp2.id)
    cliff_pairs
  join cdk2.mols ms1 on (id1=ms1.id)
  join cdk2.mols ms2 on (id2=ms2.id)
  join cdk2.molvals vs1 on (id1=vs1.id)
  join cdk2.molvals vs2 on (id2=vs2.id)
  where dist>0
) tmp
where pact1>=pact2 and (pact1-pact2)>0.1
order by disparity desc
select *, (pact1-pact2)/dist disparity, pact2-pact1 dact from
   ( select ms1.id id1, ms1.m smiles1, ms2.id id2, ms2.m smiles2, dist,
   -1*log(vs1.ic50_nm*1e-9) pact1,
   -1*log(vs2.ic50_nm*1e-9) pact2
   from
       ( select fp1.id id1, fp2.id id2,
           1.0-dice_sml(fp1.torsionfp, fp2.torsionfp) dist
           from cdk2.countfps as fp1
cross join cdk2.countfps as fp2
           where fp1.torsionfp#fp2.torsionfp and fp1.id!=fp2.id
       ) cliff_pairs
join cdk2.mols ms1 on (id1=ms1.id)
join cdk2.mols ms2 on (id2=ms2.id)
join cdk2.molvals vs1 on (id1=vs1.id)
join cdk2.molvals vs2 on (id2=vs2.id)
   where dist>0
) tmp
where pact1>=pact2 and (pact1-pact2)>.1
order by disparity desc
Matched pairs in SQL(simple)

```sql
select *, (pact1-pact2)/dist disparity, pact2-pact1 dact from
  ( select ms1.id id1, ms1.m smiles1, ms2.id id2, ms2.m smiles2, dist,
      -1*log(vs1.ic50_nm*1e-9) pact1,
      -1*log(vs2.ic50_nm*1e-9) pact2
      from ( select fp1.id id1, fp2.id id2,
            1.0-dice_sml(fp1.torsionfp, fp2.torsionfp) dist
            from cdk2.countfps as fp1
            cross join cdk2.countfps as fp2
            where fp1.torsionfp#fp2.torsionfp and fp1.id!=fp2.id
      ) cliff_pairs
      join cdk2.mols ms1 on (id1=ms1.id)
      join cdk2.mols ms2 on (id2=ms2.id)
      join cdk2.molvals vs1 on (id1=vs1.id)
      join cdk2.molvals vs2 on (id2=vs2.id)
      where dist>0
  ) tmp
where pact1>=pact2 and (pact1-pact2)>0.1
order by disparity desc
```
Matched pairs in SQL(simple)

```sql
select *, (pact1-pact2)/dist disparity, pact2-pact1 dact from
  (select ms1.id id1, ms1.m smiles1, ms2.id id2, ms2.m smiles2, dist,
   -1*log(vs1.ic50_nm*1e-9) pact1,
   -1*log(vs2.ic50_nm*1e-9) pact2
  from
    (select fp1.id id1, fp2.id id2,
     1.0-dice_sml(fp1.torsionfp, fp2.torsionfp) dist
    from cdk2.countfps as fp1
    cross join cdk2.countfps as fp2
    where fp1.torsionfp#fp2.torsionfp and fp1.id!=fp2.id
    ) cliff_pairs
  join cdk2.mols ms1 on (id1=ms1.id)
  join cdk2.mols ms2 on (id2=ms2.id)
  join cdk2.molvals vs1 on (id1=vs1.id)
  join cdk2.molvals vs2 on (id2=vs2.id)
  where dist>0
  ) tmp
where pact1>=pact2 and (pact1-pact2)> .1
order by disparity desc
```
Matched pairs in SQL (complete)

```sql
select *, (pact1-pact2)/dist disparity, pact2-pact1 dact from
  ( select ms1.id id1, ms1.m smiles1, ms2.id id2, ms2.m smiles2, dist,
    -1*log(vs1.ic50_nm*1e-9) pact1,
    -1*log(vs2.ic50_nm*1e-9) pact2,
    t4v_hash
  from ( select fp1.id id1, fp2.id id2,
    1.0-dice_sml(fp1.torsionfp, fp2.torsionfp) dist,
    md5(subtract(fp1.torsionfp, fp2.torsionfp)::text) t4v_hash
  from cdk2.countfps as fp1
  cross join cdk2.countfps as fp2
  where fp1.torsionfp#fp2.torsionfp and fp1.id!=fp2.id
  ) cliff_pairs
  join cdk2.mols ms1 on (id1=ms1.id)
  join cdk2.mols ms2 on (id2=ms2.id)
  join cdk2.molvals vs1 on (id1=vs1.id)
  join cdk2.molvals vs2 on (id2=vs2.id)
  where dist>0
) tmp
where pact1>=pact2 and (pact1-pact2)>.1
order by disparity desc
```
Performance

- Dataset: 1181 molecules with measured CDK2 IC50s (source: binding db)
- Fingerprints: topological torsions (count-based)
- Counting results:
  - Similarity cutoff 0.90: 1400 pairs, 0.39 sec
  - Similarity cutoff 0.85: 3719 pairs, 0.53 sec
  - Similarity cutoff 0.75: 11541 pairs, 0.85 sec
- Retrieving results:
  - Similarity cutoff 0.90: 1400 pairs, 2.0 sec
  - Similarity cutoff 0.85: 3719 pairs, 4.9 sec
  - Similarity cutoff 0.75: 11541 pairs, 14.1 sec
- Hardware: Dell Studio XPS (i7 870, 64bit)
Knime implementation
Knime implementation
## Knime implementation

<table>
<thead>
<tr>
<th>Row ID</th>
<th>S t4v hash</th>
<th>D Mean(...)</th>
<th>First(mol1)</th>
<th>First(mol2)</th>
<th>Count(...)</th>
<th>D Max(...pact1)</th>
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Wrapping up

What is it?
- Cheminformatics toolkit usable from C++, Python, Java
- Postgresql cartridge for substructure/similarity searching
- Open-source Knime nodes for cheminformatics

Web presence:
- Main site: http://www.rdkit.org
- Knime nodes: http://tech.knime.org/community/rdkit
We’re hiring!

- Cambridge (the US one):
  - Cheminformatics developer in the Chemical Information Systems group
  - Technical lead in the Chemical Information Systems group
- If you’re interested, please contact me
Thanks!

C++:
Core data structures and algorithms
Backups
Comparing similarity measures

- Pick 10K random pairs of vendor compounds that have at least some topological similarity to each other (Avalon similarity $\geq 0.5$)
- Compare similarities calculated with Pipeline Pilot and the RDKit
Comparing similarity measures

- **RDKit Morgan2 vs PP ECFP4**
  
  Larger differences are mostly aromaticity related.

- **RDKit Morgan3 vs PP ECFP6** is similar.
Comparing similarity measures

- **RDKit FeatMorgan2 vs PP FCFP4**

Differences are due to feature definitions:
- 84% of similarities differ by <0.05
- 95% differ by <0.1
Contributing to open source: why bother?

- Scientific argument for releasing source:
  ACS ethical guidelines: "A primary research report should contain sufficient detail and reference to public sources of information to permit the author’s peers to repeat the work." (http://pubs.acs.org/userimages/ContentEditor/1218054468605/ethics.pdf)

N. Barnes, "Publish your computer code: it is good enough" Nature 467:753 (2010)
Contributing to open source: why bother?

- Philosophy

  - Improved code quality: users = testers/peer reviewers
  
  - Gather new ideas/contributions from others
  
  - Altruism: give something back to "the community"
  
  - Selfishness: guarantee your own access to your work
Contributing to open source: why bother?

- We aren't the only big company doing this:
  - IBM
  - Apple
  - Google
  - Nokia
  - Microsoft(!)
  - many, many others

- We aren't even the only pharma company:
  - Sunesis
  - Lilly
  - Boehringer Ingelheim
  - Astra Zeneca
  - Sanofi Aventis
  - others
Practical Considerations

- Precompetitive

- Treat code publication process the same as publication of a scientific paper

- Pick a license carefully; use a standard one

- Management understanding and support

- Support from legal/patent department