Announcements

• Course survey due Monday 4/20 @ 11:59pm
• If 85% of students complete the course survey on resources, everyone gets 1 bonus point! [http://goo.gl/ajEBkT](http://goo.gl/ajEBkT)

• Project 4 due Thursday 4/23 @ 11:59pm
  ▪ Early point #2: All questions (including Extra Credit) by Wednesday 4/22 @ 11:59pm

• Recursive Art Contest Entries due Monday 4/27 @ 11:59pm
  ▪ Email your code & a screenshot of your art to [cs61a-tae@imail.eecs.berkeley.edu](mailto:cs61a-tae@imail.eecs.berkeley.edu) (Albert)

• Homework 9 merged with Homework 10; both are due Wednesday 4/29 @ 11:59pm
Local Tables
Local Tables

A `create table` statement names a table globally

```sql
create table parents as
select "abraham" as parent, "barack" as child union
select "abraham", "clinton" union
select "delano", "herbert" union
select "fillmore", "abraham" union
select "fillmore", "delano" union
select "fillmore", "grover" union
select "eisenhower", "fillmore";
```

<table>
<thead>
<tr>
<th>Parent</th>
<th>Child</th>
</tr>
</thead>
<tbody>
<tr>
<td>abraham</td>
<td>barack</td>
</tr>
<tr>
<td>abraham</td>
<td>clinton</td>
</tr>
<tr>
<td>delano</td>
<td>herbert</td>
</tr>
<tr>
<td>fillmore</td>
<td>abraham</td>
</tr>
<tr>
<td>fillmore</td>
<td>delano</td>
</tr>
<tr>
<td>fillmore</td>
<td>grover</td>
</tr>
<tr>
<td>eisenhower</td>
<td>fillmore</td>
</tr>
</tbody>
</table>
Local Tables

A create table statement names a table globally

A with clause of a select statement names a table that is local to the statement

create table parents as
  select "abraham" as parent, "barack" as child union

... Part of the select statement

with
  best(dog) as (  
    select "eisenhower" union
    select "barack"
  )

select parent from parents, best where child=dog;

<table>
<thead>
<tr>
<th>parent</th>
</tr>
</thead>
<tbody>
<tr>
<td>abraham</td>
</tr>
</tbody>
</table>

local table only exists for this select

parents:

Eisenhower
Fillmore
Abraham
Delano
Grover
Barack
Clinton
Herbert
(Demo)
Example: Relationships

(A) What are appropriate names for the columns in this result?

(B) How many rows will result?

```sql
with siblings
what(first, second) as (  
    select a.child, b.child  
    from parents as a, parents as b  
    where a.parent = b.parent and  
    a.child != b.child
)
select child as __________, second as __________  
from parents, what where parent=first;
```

<table>
<thead>
<tr>
<th>parent</th>
<th>child</th>
<th>first</th>
<th>second</th>
</tr>
</thead>
<tbody>
<tr>
<td>abraham</td>
<td>barack</td>
<td>abraham</td>
<td>delano</td>
</tr>
</tbody>
</table>
Recursive Local Tables
Local Tables can be Declared Recursively

An ancestor is your parent or an ancestor of your parent

```sql
create table parents as
  select "abraham" as parent, "barack" as child union ...

with
  ancestors(ancestor, descendent) as ( 
    select parent, child from parents union
    select ancestor, child 
    from ancestors, parents
    where parent = descendent
  )
select ancestor from ancestors where descendent="herbert";
```
Global Names for Recursive Tables

To create a table with a global name, you need to select the contents of the local table

```sql
create table odds as
with
  odds(n) as (  
    select 1 union
    select n+2 from odds where n < 15;
  )
select n from odds;
```

Which names above can change without affecting the result?
Limits on Recursive Select Statements

Recursive table definitions are only possible within a with clause.

No mutual recursion: two or more tables cannot be defined in terms of each other.

```sql
with
  odds(x) as (  
    select 1 union select x+1 from evens
  ),
  evens(x) as (  
    select x+1 from odds
  )
select x from odds
```

No tree recursion: the table being defined can only appear once in a from clause.

```sql
with
  ints(x) as (  
    select 1 union select x-1 from ints union select x+1 from ints
  )
select x from ints;
```

```
with
  ints(x) as (  
    select 1 union select a.x + b.x from ints as a, ints as b
  )
select x from ints;
```
String Examples
Language is Recursive

Noun phrases can contain relative pronouns that introduce relative clauses

The dog chased the cat

that chased the bird

The dog chased the cat

that the bird chased

The dog chased the cat

the bird chased

The dog the bird the cat chased chased chased chased me

Bulldogs bulldogs bulldogs fight fight fight

(Demo)
Integer Examples
Input-Output Tables

A table containing the inputs to a function can be used to map from output to input

```sql
create table pairs as
  with
    i(n) as (  
      select 1 union
      select n+1 from i where n < 50
    )
  select a.n as x, b.n as y from i as a, i as b where a.n <= b.n;
```

What integers can I add/multiply together to get 24?

(Demo)
Example: Pythagorean Triples

All triples \(a, b, c\) such that \(a^2 + b^2 = c^2\)

with

\[
i(n) \text{ as (}
\text{select 1 union select } n+1 \text{ from } i \text{ where } n < 20
\}
\]

\[
\text{select } a.n \text{ as } a, \text{ b.n as } b, \text{ c.n as } c
\]

\[
\text{from } \text{ i as a, i as b, i as c}
\]

\[
\text{where } a.n < b.n \text{ and } a.n*a.n + b.n*b.n = c.n*c.n;
\]
Example: Fibonacci Sequence

Computing the next Fibonacci number requires both the previous and current numbers

```sql
create table fibs as
with
  fib(previous, current) as (
    select 0, 1 union
    select current, previous + current from fib
  where current <= 14.15926535
  )
select previous as n from fib;
```

<table>
<thead>
<tr>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>13</td>
</tr>
</tbody>
</table>
A Very Interesting Number

The mathematician G. H. Hardy once remarked to the mathematician Srinivasa Ramanujan...