Principles of Database Systems (CS307)

Lecture 9-1: Function

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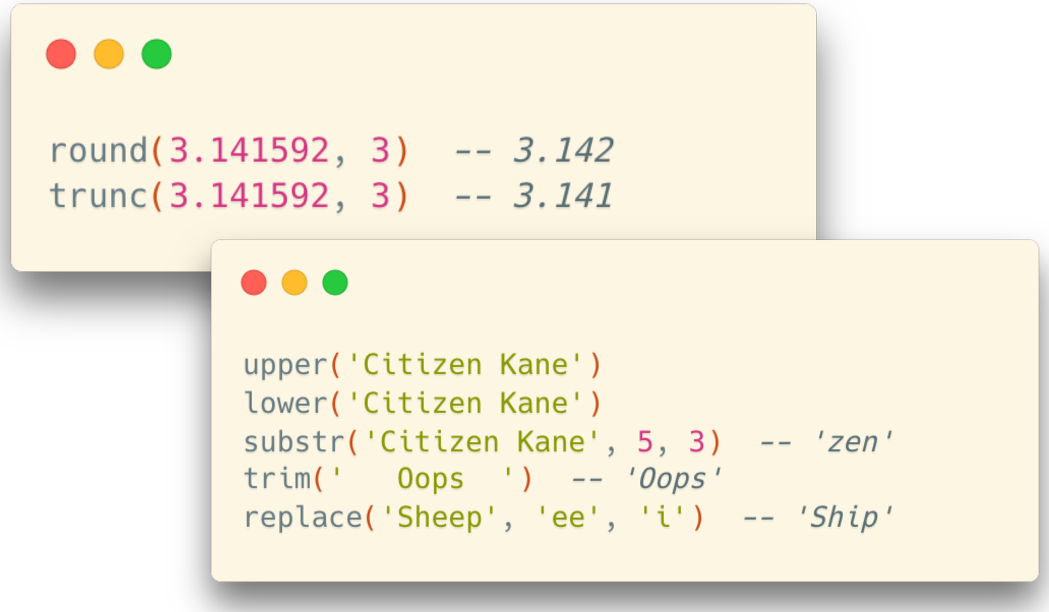
- Most contents are from slides made by Stéphane Faroult and the authors of Database System Concepts (7th Edition).
- Their original slides have been modified to adapt to the schedule of CS307 at SUSTech.

Function

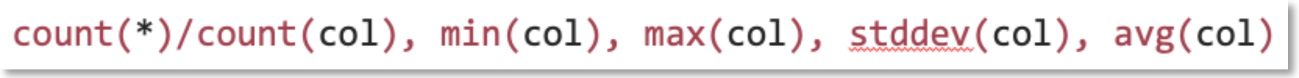
Built-in Functions

- Most DBMS provides a series of built-in functions
  - E.g., Scalar function, aggregation function, window function

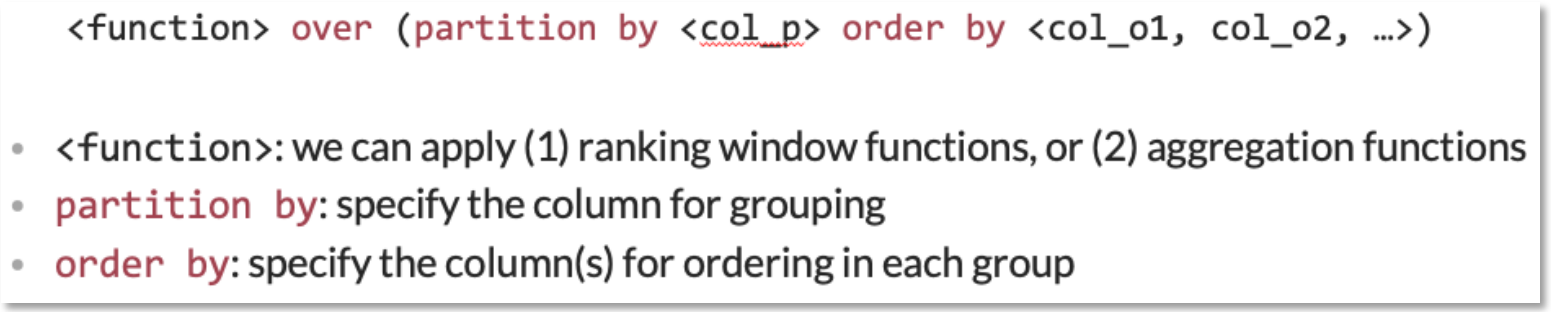


```
round(3.141592, 3)  -- 3.142
trunc(3.141592, 3)  -- 3.141
```

```
upper('Citizen Kane')
lower('Citizen Kane')
substr('Citizen Kane', 5, 3)  -- 'zen'
trim('   Oops  ')  -- 'Oops'
replace('Sheep', 'ee', 'i')  -- 'Ship'
```



```
count(*)/count(col), min(col), max(col), stddev(col), avg(col)
```



```
<function> over (partition by <col_p> order by <col_o1, col_o2, …>)
```

- <function>: we can apply (1) ranking window functions, or (2) aggregation functions
- partition by: specify the column for grouping
- order by: specify the column(s) for ordering in each group

Self-defined Function

- Sometimes the built-in functions cannot fulfill our requirements
    - And the power of declarative language (SQL) is not enough

- Most DBMS implement a built-in, SQL-based programming language
    - A procedural extension to SQL

Procedural vs. Declarative

- Two different programming paradigms
  - Imperative: Describe the algorithms step-by-step (How to do)
    - Procedural: C (and many other legacy languages)
    - Object-oriented: Java
  - Declarative: Describe the result without specifying the detailed steps (What to do)
    - (Pure) declarative: SQL, Regular Expressions, Markup (HTML, XML), CSS
    - Functional: Scheme, Haskell, Scala, Erlang
    - Logic programming: Prolog

Procedural vs. Declarative

- E.g., How can we get a cup of tea?
  - In a procedural way:

  - In a declarative way:

Procedural vs. Declarative

- E.g., How can we get a cup of tea?
  - In a procedural way:

1. Get a cup
2. Get some tea
3. Get some hot water
4. Put tea into the cup
5. Pour hot water into the cup
6. `return tea;`

  - In a declarative way:

Procedural vs. Declarative

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1. Get a cup
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6. `return tea;`

- In a declarative way:

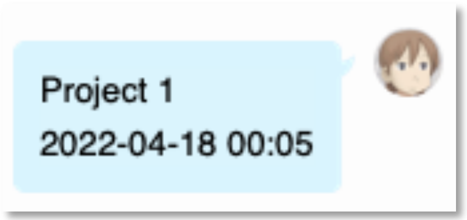
<a cup of tea/>

  - You don’t really need to know how to make a cup of tea
  - The system can do it in a black-box manner

Procedural vs. Declarative

- E.g., Find all Chinese movies before 1990 in the `movies` table?
  - In a procedural way:

```
1. Read the movies table into the memory
2. For each row i in the table, repeat:
2.1 In row i, read the value of the column "country"
2.2 if …
```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- In a declarative way:

```
select * from movies where country = ‘cn’ and year_released < 1990
```

  - You don't really need to know how to filter the table
  - The DBMS system can do it in a black-box manner

Procedural vs. Declarative

- Benefits in declarative languages
  - No need to understand the details
    - The systems take in charge of all the details
  - Easier to use than imperative programming
    - More user-friendly

- Problem in declarative languages
  - Cannot specify the control flow of a program
    - “If there is no such command as <a cup of tea/>, you need to create it by yourself”

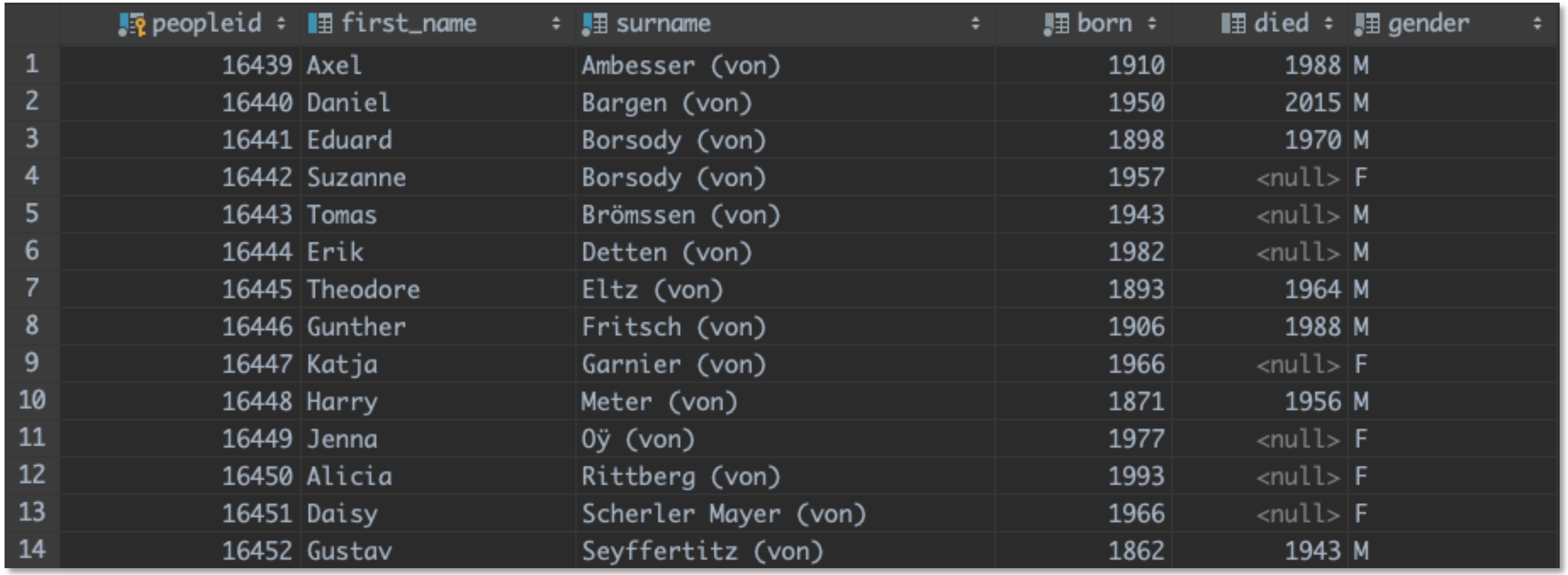
Procedural Extension to SQL

- Many DBMS products provide a proprietary procedural extension to the standard SQL
  - Transact-SQL (T-SQL)
  - PL/SQL
  - PL/PGSQL
  - (No specific name)
  - (Not supported)

… well, sometimes SQLite is even not considered a DBMS

Function in (Postgre)SQL

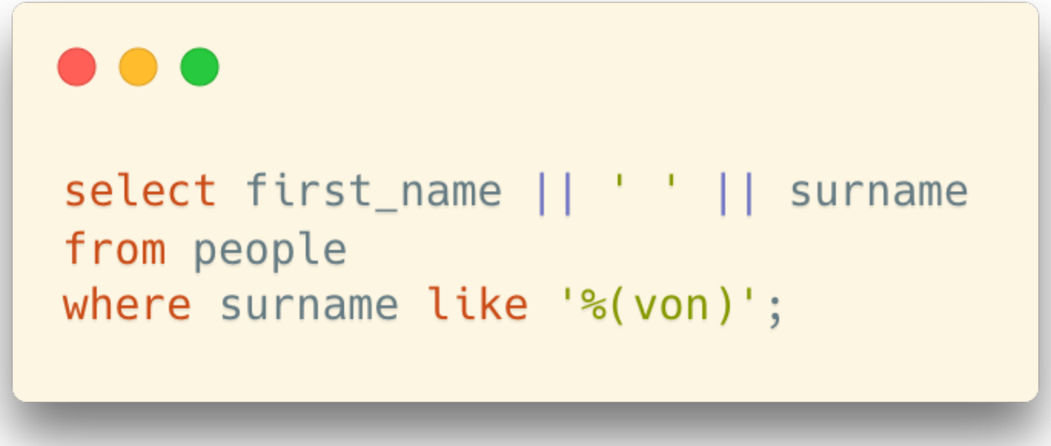
- Example: Display the full name for people with "von"
  - When introducing `update`, we have modified the names starting with "von" into "… (von)" for ordering



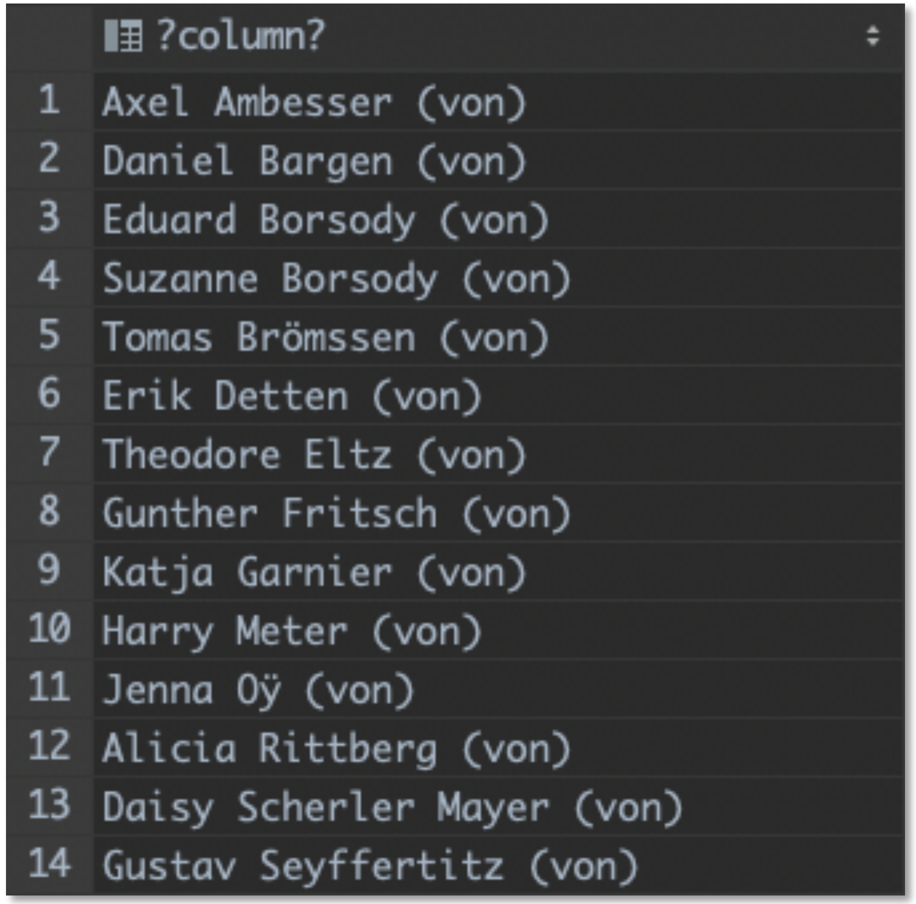
	peopleid	first_name	surname	born	died	gender
1	16439	Axel	Ambesser (von)	1910	1988	M
2	16440	Daniel	Bargen (von)	1950	2015	M
3	16441	Eduard	Borsody (von)	1898	1970	M
4	16442	Suzanne	Borsody (von)	1957	<null>	F
5	16443	Tomas	Brömssen (von)	1943	<null>	M
6	16444	Erik	Detten (von)	1982	<null>	M
7	16445	Theodore	Eltz (von)	1893	1964	M
8	16446	Gunther	Fritsch (von)	1906	1988	M
9	16447	Katja	Garnier (von)	1966	<null>	F
10	16448	Harry	Meter (von)	1871	1956	M
11	16449	Jenna	Oÿ (von)	1977	<null>	F
12	16450	Alicia	Rittberg (von)	1993	<null>	F
13	16451	Daisy	Scherler Mayer (von)	1966	<null>	F
14	16452	Gustav	Seyffertitz (von)	1862	1943	M

Function in (Postgre)SQL

- If we simply concatenate the first name and the last name, it looks like this:
  - A little bit weird format (a trailing “von”)



```
select first_name || ' ' || surname
from people
where surname like '%(von)';
```



```
    ?column?
1   Axel Ambesser (von)
2   Daniel Bargen (von)
3   Eduard Borsody (von)
4   Suzanne Borsody (von)
5   Tomas Brömssen (von)
6   Erik Detten (von)
7   Theodore Eltz (von)
8   Gunther Fritsch (von)
9   Katja Garnier (von)
10  Harry Meter (von)
11  Jenna Oÿ (von)
12  Alicia Rittberg (von)
13  Daisy Scherler Mayer (von)
14  Gustav Seyffertitz (von)
```

Function in (Postgre)SQL

- Question: How can we restore the format into “first_name von surname”?
    - String operations

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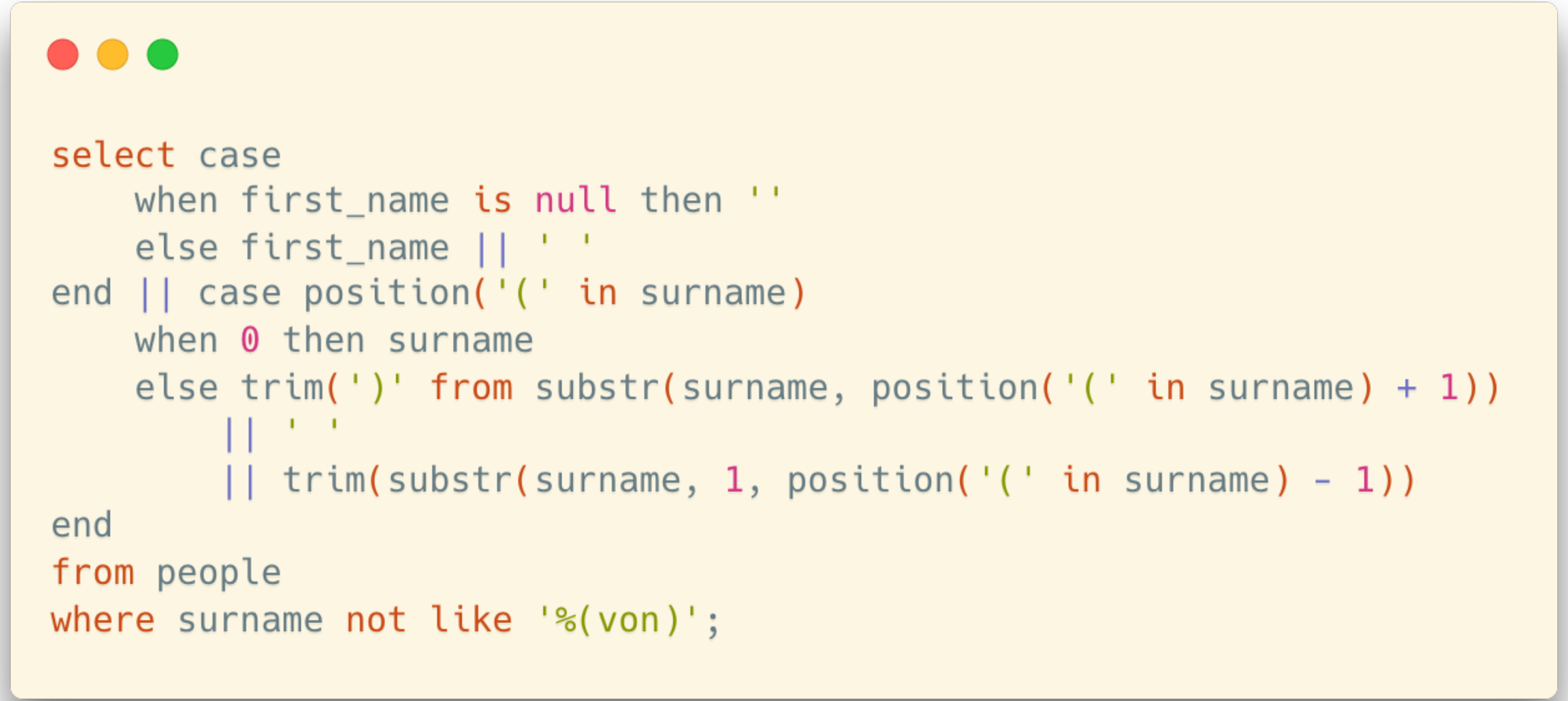
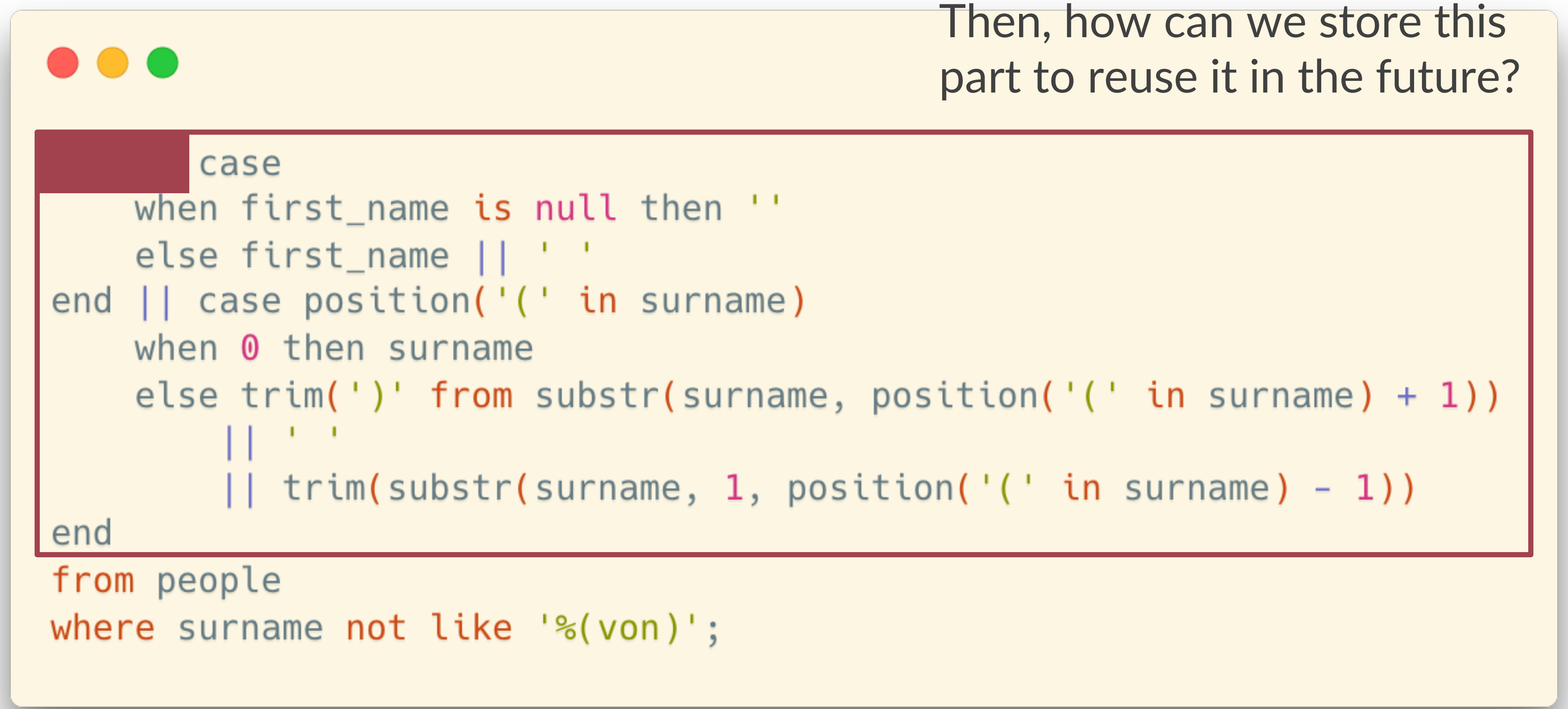


```sql
select case
    when first_name is null then ''
    else first_name || ' '
end || case position('(' in surname)
    when 0 then surname
    else trim(')' from substr(surname, position('(' in surname) + 1))
        || ' '
        || trim(substr(surname, 1, position('(' in surname) - 1))
end
from people
where surname not like '%(von)';
```

Function in (Postgre)SQL

- Question: How can we restore the format into “first_name von surname”?
    - String operations

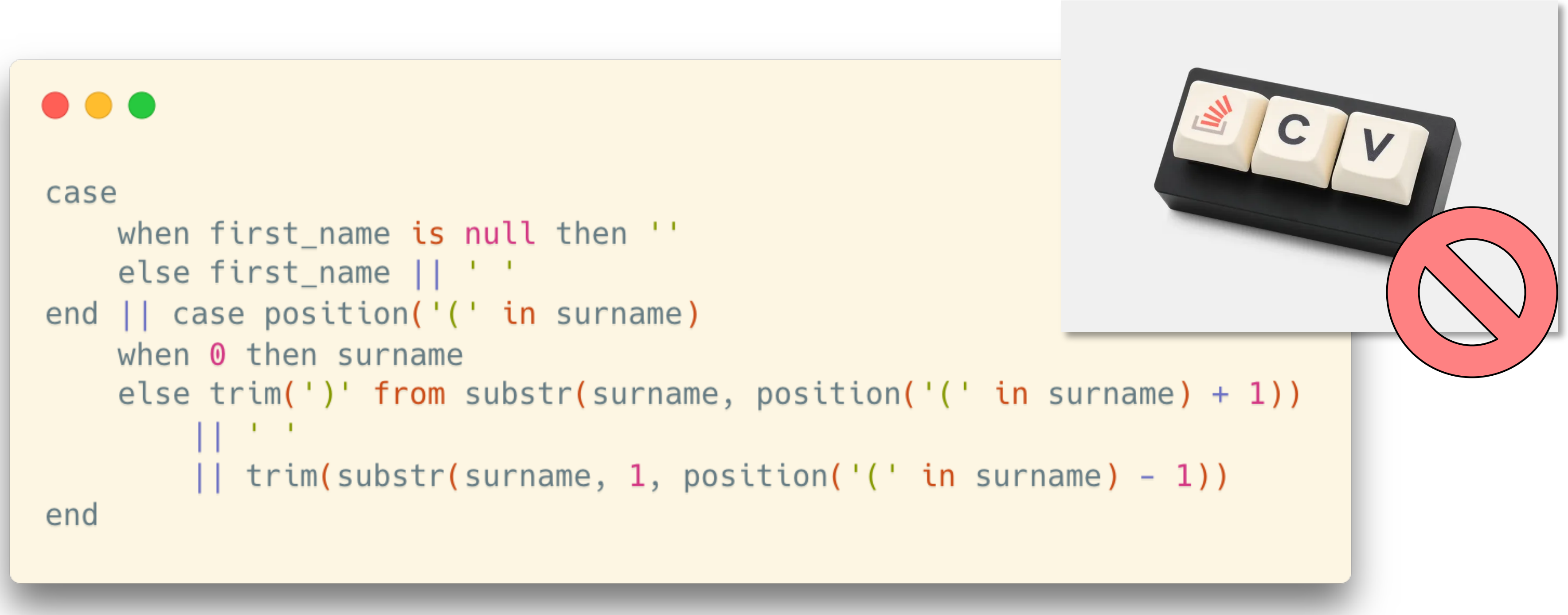


Then, how can we store this part to reuse it in the future?

```
[redacted] case
    when first_name is null then ''
    else first_name || ' '
end || case position('(' in surname)
    when 0 then surname
    else trim(')' from substr(surname, position('(' in surname) + 1))
        || ' '
        || trim(substr(surname, 1, position('(' in surname) - 1))
end
from people
where surname not like '%(von)';
```

Function in (Postgre)SQL

- “Copy and paste” is not a good habit
  - Whenever you have painfully written something as complicated, which is pretty generic, you'd rather not copy and paste the code every time you need it



```
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end || case position('(' in surname)
    when 0 then surname
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        || ' '
        || trim(substr(surname, 1, position('(' in surname) - 1))
end
```
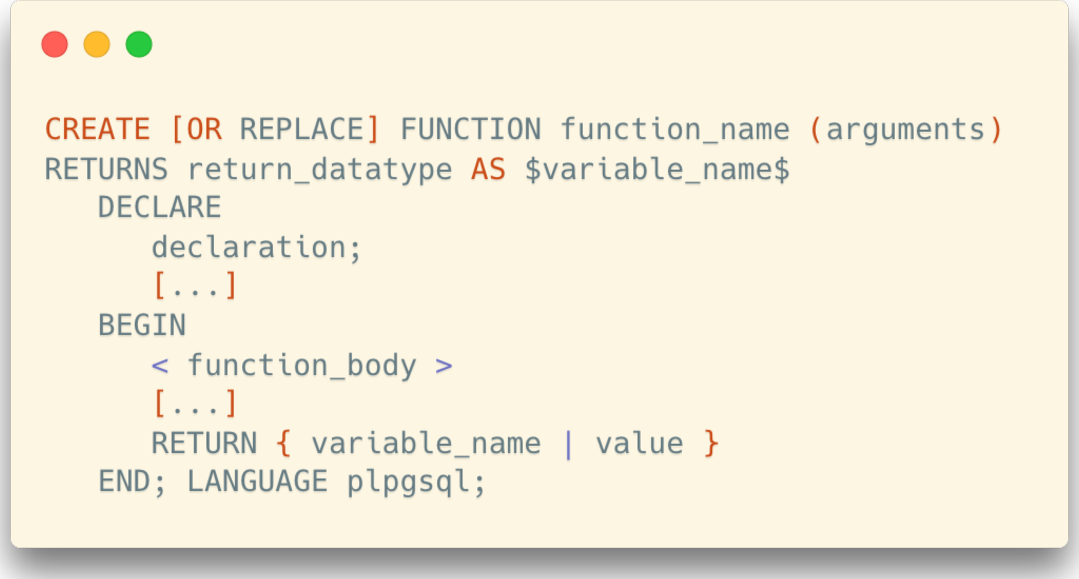
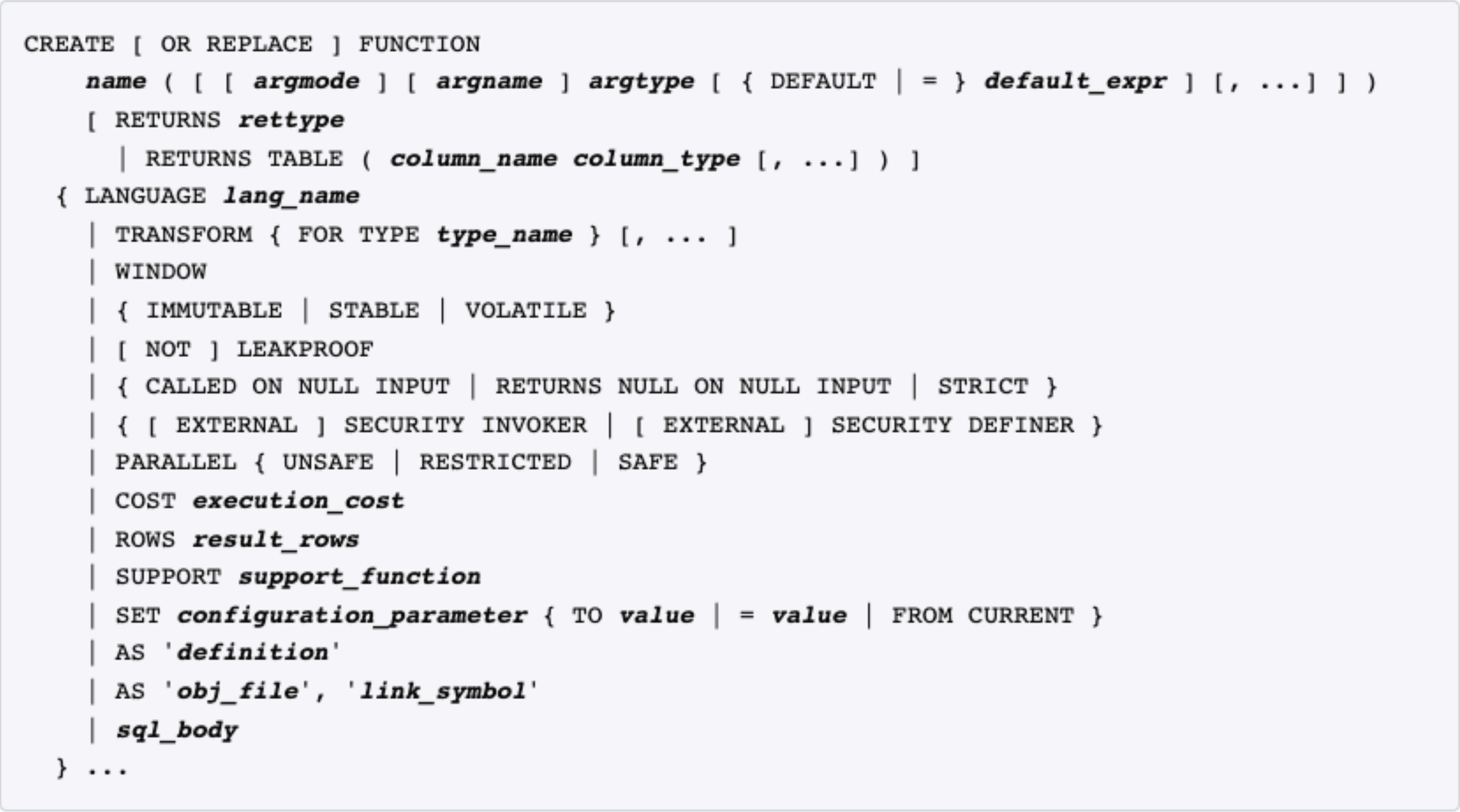

Function in (Postgre)SQL

- Store for Reuse
  - In PostgreSQL, we can store the expression and reuse it in another context
- Self-defined Function
  - `create function`



```
CREATE [OR REPLACE] FUNCTION function_name (arguments)
RETURNS return_datatype AS $variable_name$
   DECLARE
      declaration;
      [...]
   BEGIN
      < function_body >
      [...]
      RETURN { variable_name | value }
   END; LANGUAGE plpgsql;
```

...or, a simpler version

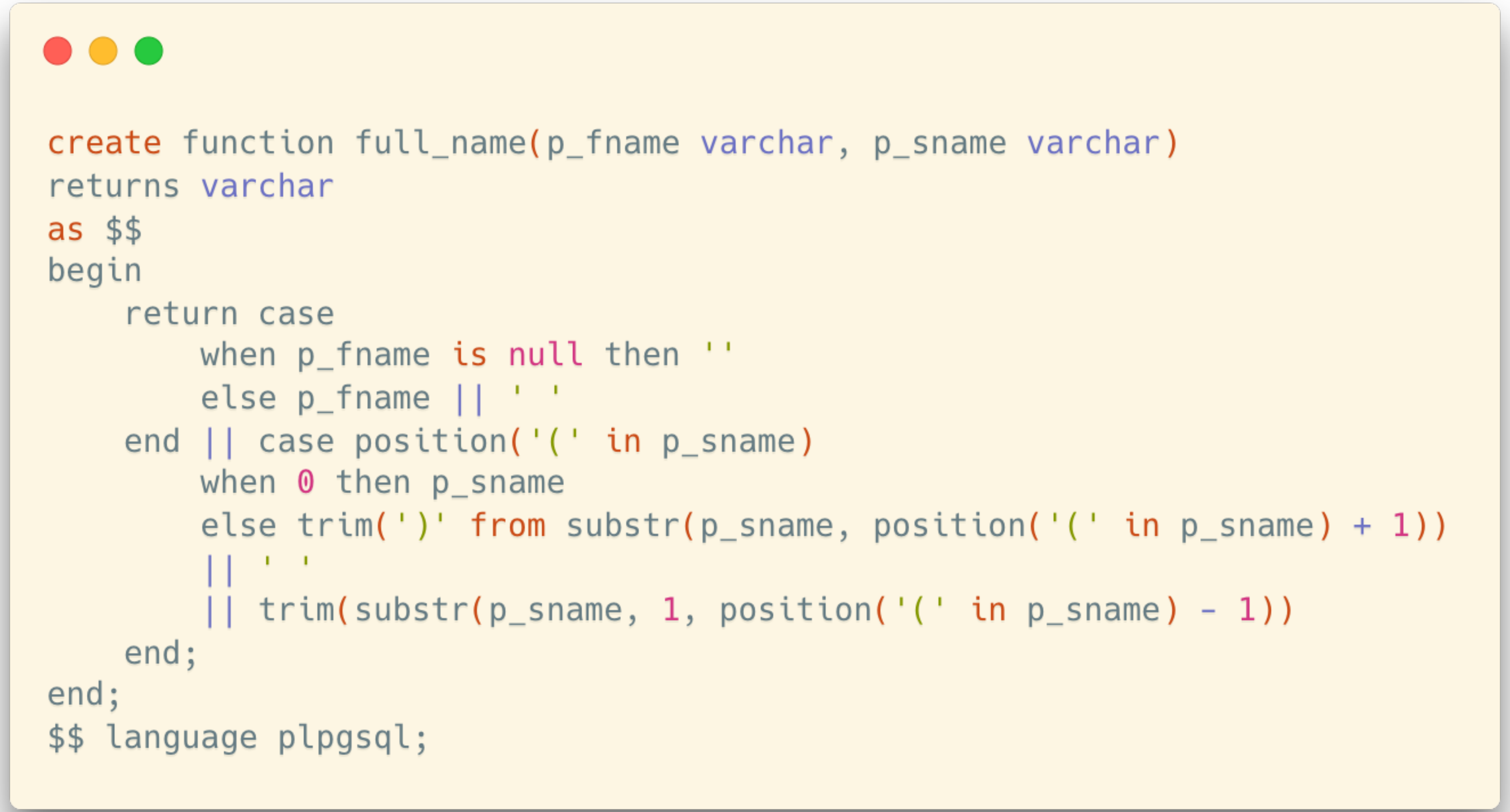


```
CREATE [ OR REPLACE ] FUNCTION
    name ( [ [ argmode ] [ argname ] argtype [ { DEFAULT | = } default_expr ] [, ...] ] )
    [ RETURNS rettype
      | RETURNS TABLE ( column_name column_type [, ...] ) ]
  { LANGUAGE lang_name
    | TRANSFORM { FOR TYPE type_name } [, ... ]
    | WINDOW
    | { IMMUTABLE | STABLE | VOLATILE }
    | [ NOT ] LEAKPROOF
    | { CALLED ON NULL INPUT | RETURNS NULL ON NULL INPUT | STRICT }
    | { [ EXTERNAL ] SECURITY INVOKER | [ EXTERNAL ] SECURITY DEFINER }
    | PARALLEL { UNSAFE | RESTRICTED | SAFE }
    | COST execution_cost
    | ROWS result_rows
    | SUPPORT support_function
    | SET configuration_parameter { TO value | = value | FROM CURRENT }
    | AS 'definition'
    | AS 'obj_file', 'link_symbol'
    | sql_body
  } ...
```

https://www.postgresql.org/docs/current/sql-createfunction.html

Function in (Postgre)SQL

- How do we rewrite the name conversion expression into a function?



```sql
create function full_name(p_fname varchar, p_sname varchar)
returns varchar
as $$
begin
    return case
        when p_fname is null then ''
        else p_fname || ' '
    end || case position('(' in p_sname)
        when 0 then p_sname
        else trim(')' from substr(p_sname, position('(' in p_sname) + 1))
        || ' '
        || trim(substr(p_sname, 1, position('(' in p_sname) - 1))
    end;
end;
$$ language plpgsql;
```

Function in (Postgre)SQL

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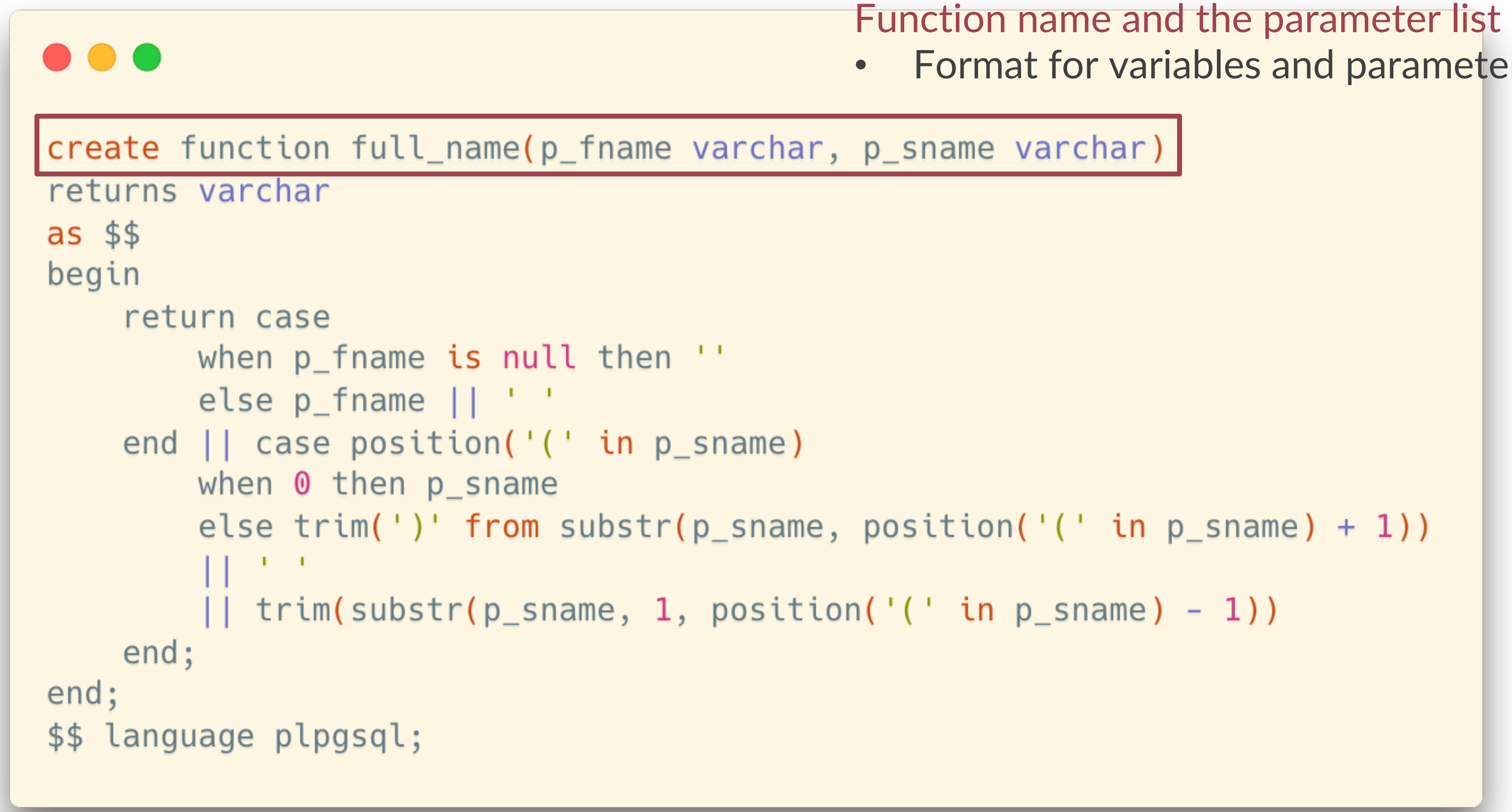

Function name and the parameter list

- Format for variables and parameters: [name] [type]

```
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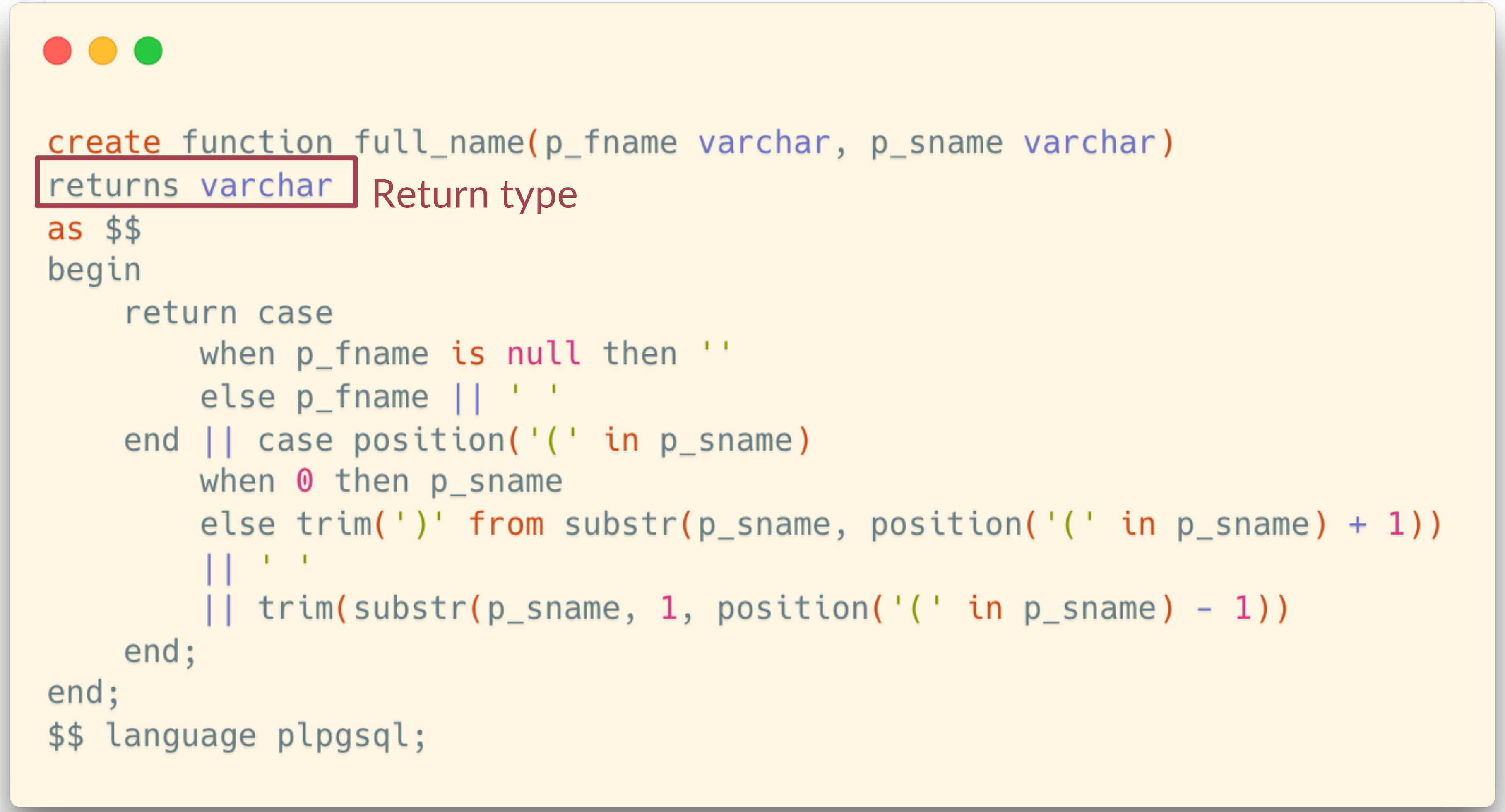

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    end;
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```

Return type

Function in (Postgre)SQL

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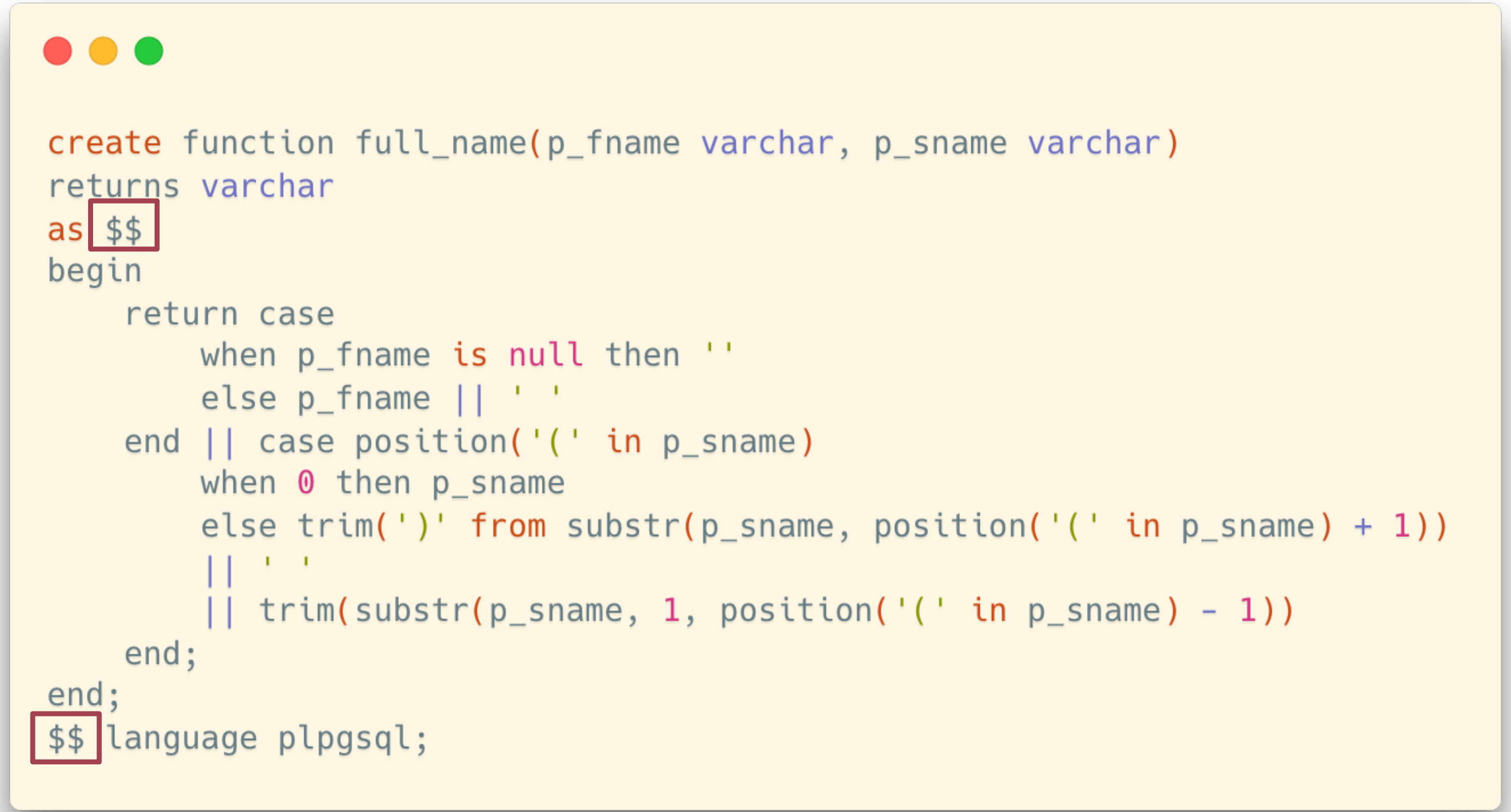

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    end;
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```

Body

Function in (Postgre)SQL

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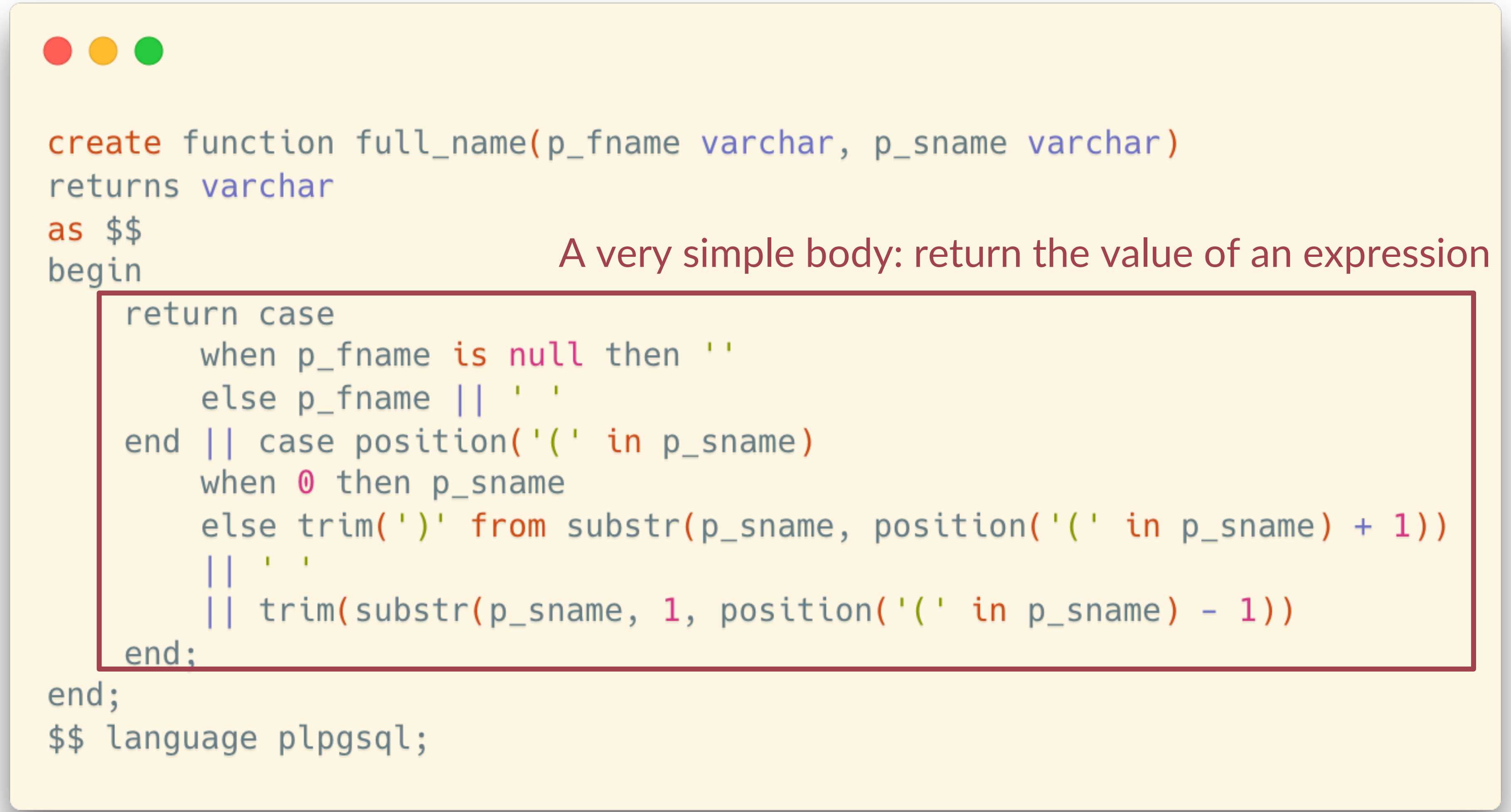

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```

A very simple body: return the value of an expression

Function in (Postgre)SQL

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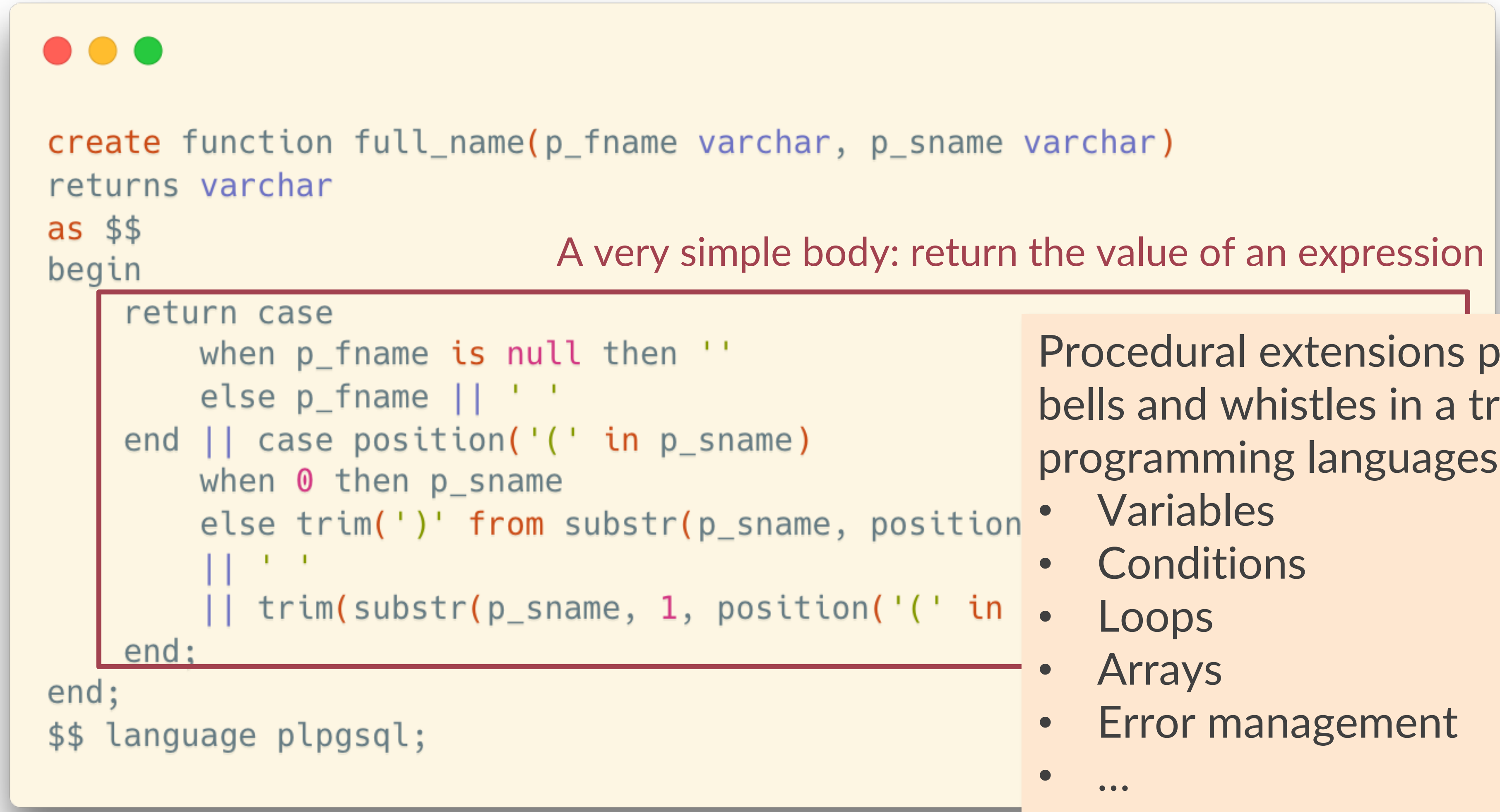

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        else trim(')' from substr(p_sname, position
        || ' '
        || trim(substr(p_sname, 1, position('(' in
    end;
end;
$$ language plpgsql;
```

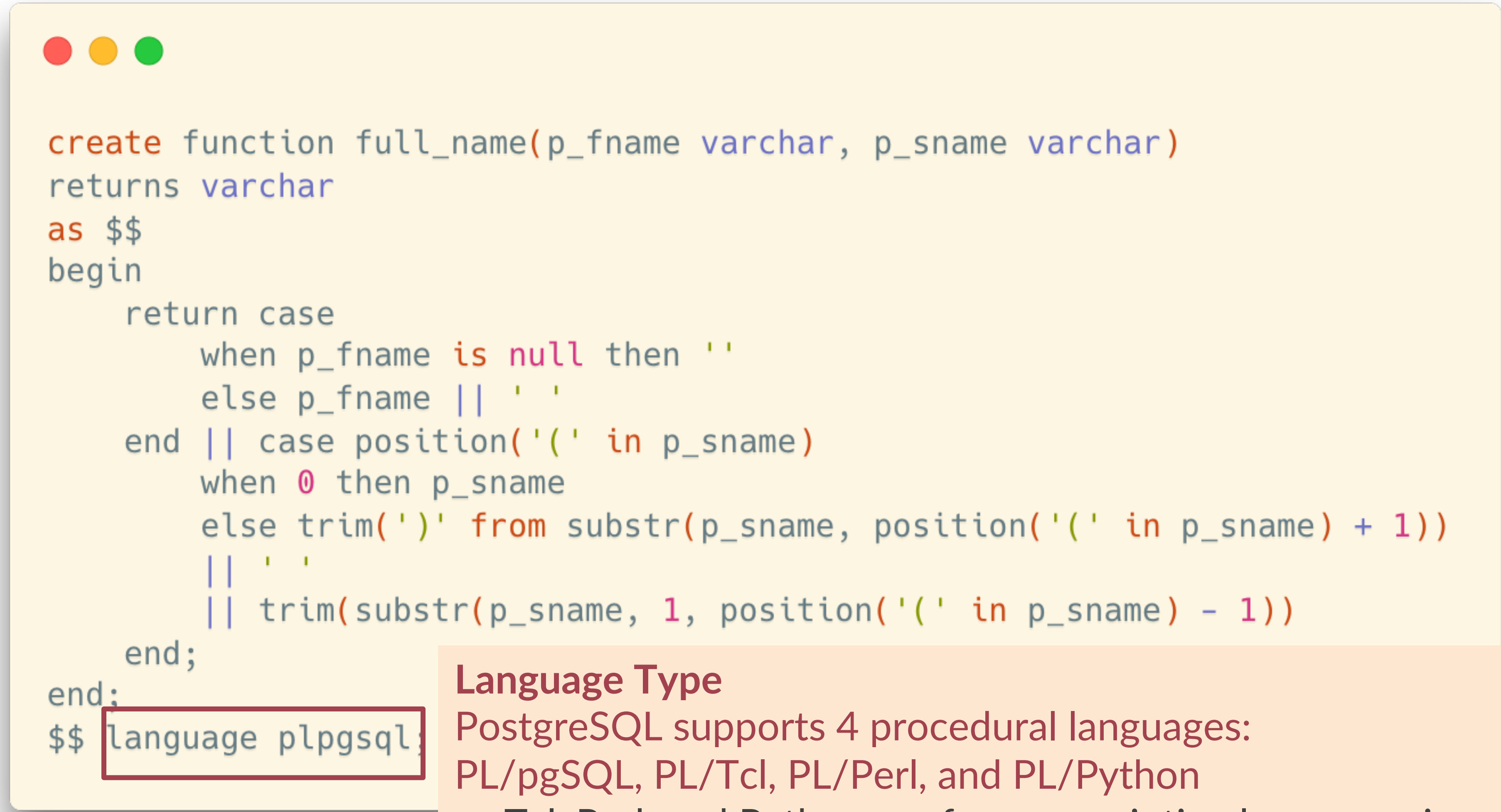
A very simple body: return the value of an expression

Procedural extensions provide all the bells and whistles in a true (procedural) programming languages, such as:

- Variables
- Conditions
- Loops
- Arrays
- Error management
- …

Function in (Postgre)SQL

- How do we rewrite the name conversion expression into a function?



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        || ' '
        || trim(substr(p_sname, 1, position('(' in p_sname) - 1))
    end;
end;
$$ language plpgsql;
```

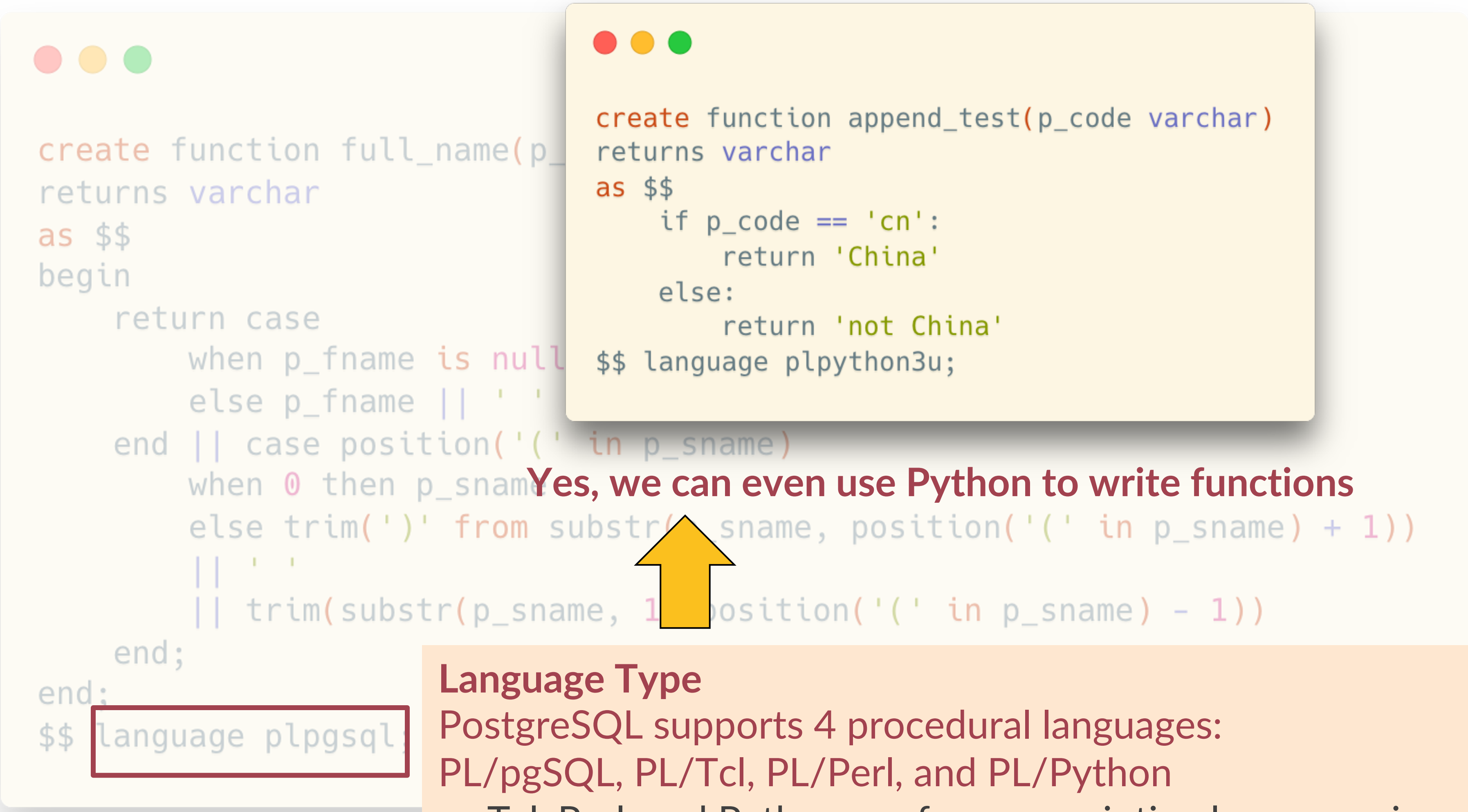
Language Type

PostgreSQL supports 4 procedural languages:
PL/pgSQL, PL/Tcl, PL/Perl, and PL/Python

- Tcl, Perl, and Python are famous scripting languages in case you don't know

Function in (Postgre)SQL

- How do we rewrite the name conversion expression into a function?



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        || ' '
        || trim(substr(p_sname, 1  osition('(' in p_sname) - 1))
    end;
end;
$$ language plpgsql
```

```
create function append_test(p_code varchar)
returns varchar
as $$
    if p_code == 'cn':
        return 'China'
    else:
        return 'not China'
$$ language plpython3u;
```

Yes, we can even use Python to write functions

Language Type

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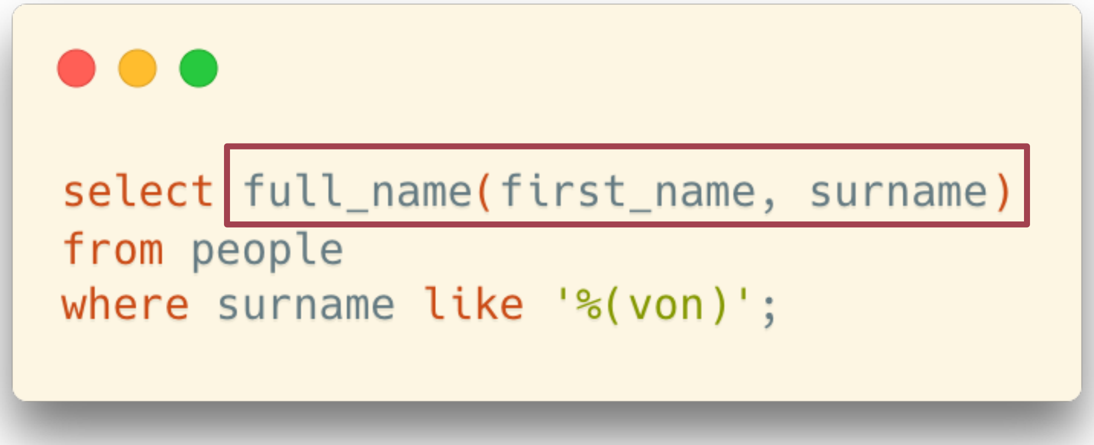
PL/pgSQL, PL/Tcl, PL/Perl, and PL/Python

- Tcl, Perl, and Python are famous scripting languages in case you don’t know

Function in (Postgre)SQL

- Once your function is created, you can use it as if it were any built-in function.



```sql
select full_name(first_name, surname)
from people
where surname like '%(von)';
```

Function in (Postgre)SQL

- We can run `select` queries in functions
  - Example: design a function “get_country_name” to transform the country codes into country names based on the `countries` table

Function in (Postgre)SQL

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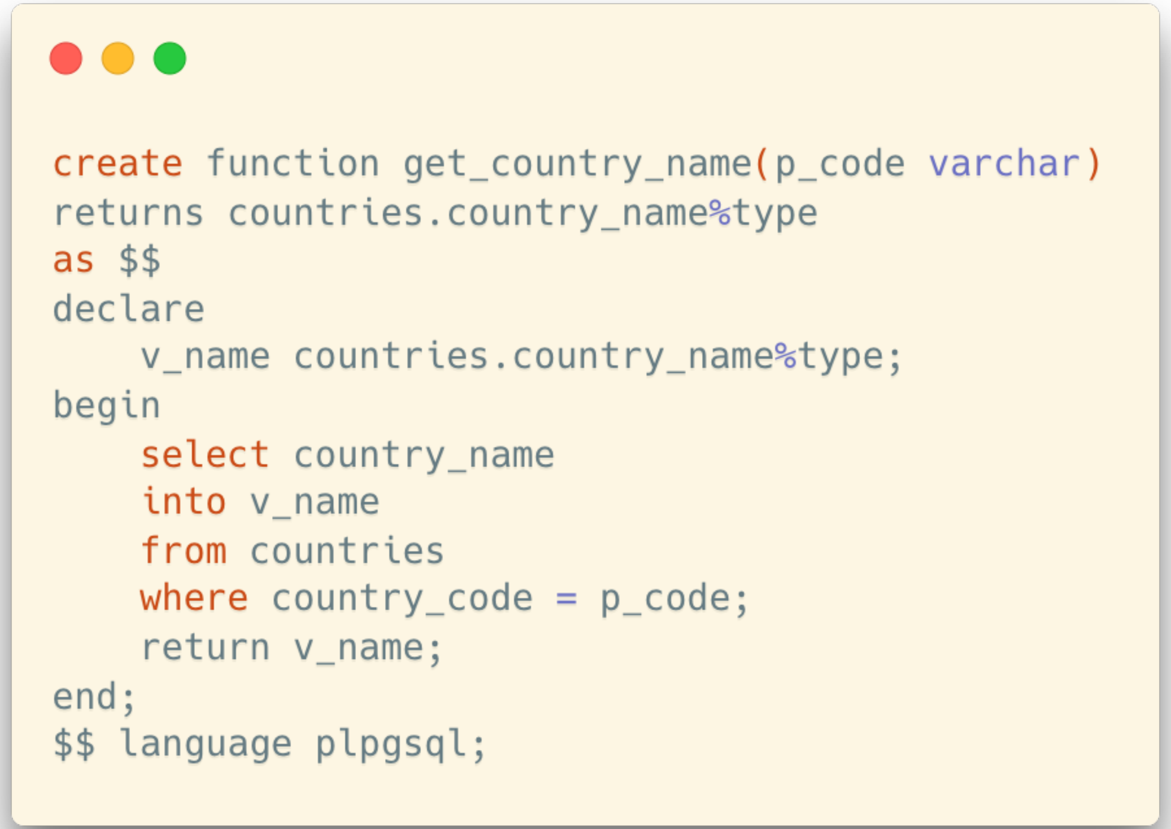
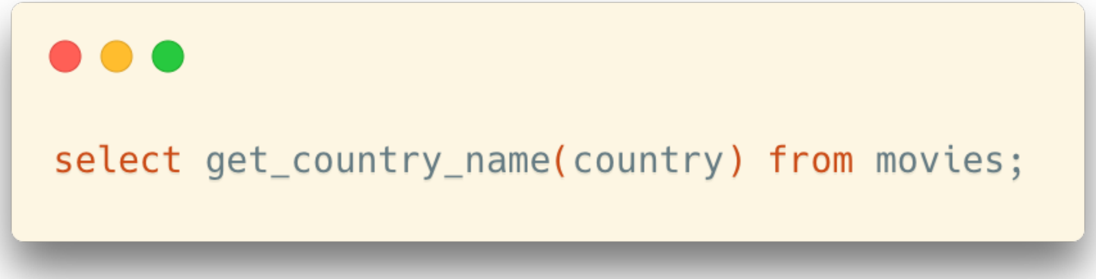


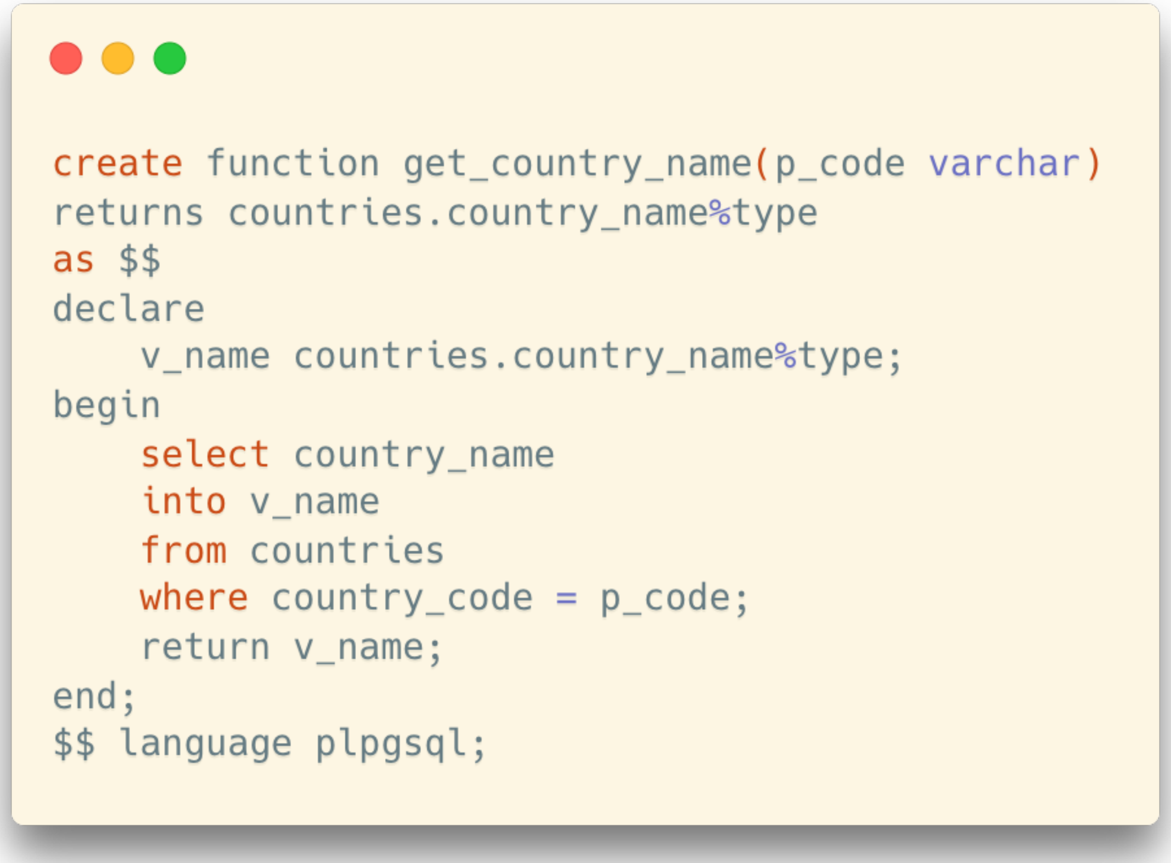
```
create function get_country_name(p_code varchar)
returns countries.country_name%type
as $$
declare
    v_name countries.country_name%type;
begin
    select country_name
    into v_name
    from countries
    where country_code = p_code;
    return v_name;
end;
$$ language plpgsql;
```



```
select get_country_name(country) from movies;
```

Function in (Postgre)SQL

- We can run `select` queries in functions
  - Example: design a function “get_country_name” to transform the country codes into country names based on the `countries` table



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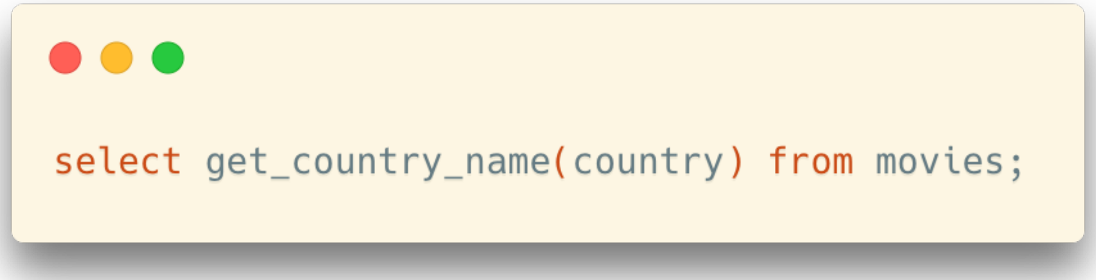
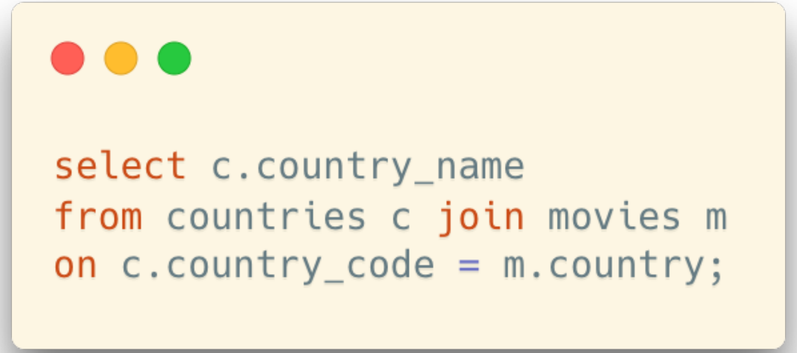


```
select get_country_name(country) from movies;
```

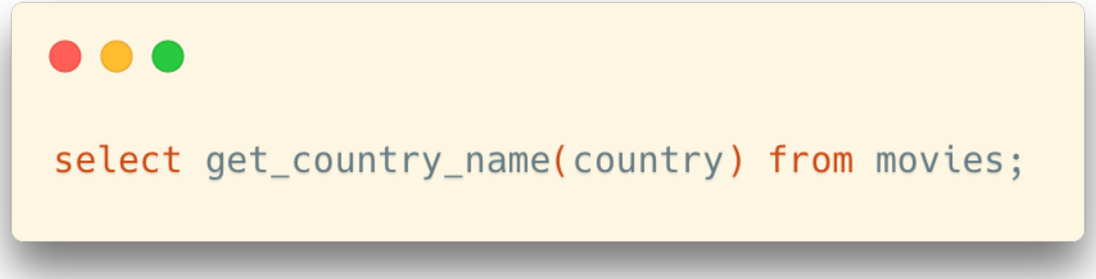
... seems to be an easy way to get rid of `join` operations?



```
select c.country_name
from countries c join movies m
on c.country_code = m.country;
```

Function in (Postgre)SQL

- "Cultural Mismatch"
  - Here we have a problem, because there is a big cultural gap between the relational mindset and procedural processing.
  - A "look-up function" forces a "one row at a time" join which in most cases will be dreadful



```
select get_country_name(country) from movies;
```

For each row in movies, the `select` query in `get_country_name()` is executed once

Comment on Procedural SQL (PL/SQL)

- **Tom Kyte**, who is a Senior Technology Architect at Oracle, says that his mantra is:
  - You should do it in a single SQL statement if at all possible.
  - If you cannot do it in a single SQL statement, then do it in PL/SQL (as little PL/SQL as possible!)

- And some other suggestions (from your lecturer):
  - You should ask for help from someone more experienced than you
    - Stackoverflow, forums, Google, etc.

More to Read

- We may not cover all the details in functions in the theoretical session, so here are some more materials on procedural programming in PostgreSQL:
  - Lab tutorial on Functions
    - Please read it before your next lab sessions
  - Chapter 5.2 “Functions and Procedures,” Database System Concepts (7th Edition)
  - Chapter 43 “PL/pgSQL,” PostgreSQL Documentation
    - https://www.postgresql.org/docs/current/plpgsql.html