Structured Query Language
SQL - DDL

- SQL Overview
- SQL Datatypes
- DDL statements

Basic SQL-DDL COMMANDS

- For database schemas:
  CREATE SCHEMA, DROP SCHEMA
- For tables:
  CREATE TABLE, DROP TABLE, ALTER TABLE
- For domains:
  CREATE DOMAIN, DROP DOMAIN [SQL99]
- For views:
  CREATE VIEW, DROP VIEW
- For integrity constraints
  CREATE IC, DROP IC

  For Indexes [defunct in SQL2]

SQL Datatypes

- Numeric
  - Fixed numbers, approximate numbers, formatted numbers
- Character Strings
  - fixed & varying length, CLOBS [SQL99], foreign language
- Bit Strings
  - fixed & varying length, BLOBS [SQL99]
- Temporal Data
  - date, time and timestamp, intervals
- **NULL** value valid for all types

SQL Numeric Data

- Exact Numbers: Two integer types with different ranges:
  - INTEGER (or INT) and SMALLINT
  - The range of numeric types is implementation dependent
- Approximate Numbers: Three floating point types:
  - FLOAT[precision], REAL, and DOUBLE PRECISION
  - Users can define the precision for FLOAT
  - The precision of REAL and DOUBLE PRECISION is fixed
  - Floating point numbers can in decimal or scientific notation
- Formatted Numbers: These are decimal numbers
  - DECIMAL(i,j), DEC(i,j) or NUMERIC(i,j)
  - **i** = precision (the total # of digits excluding decimal point)
  - **j** = scale (the # of fractional digits. The default is zero)

Observations on Numeric types

- They are like the datatype in C
  - BIGINT for long integer or integer
- Truncation is towards 0
- Rounding is business instead of Scientific
  - [0..4] ↓ 0 [0..4] ↓ 0
  - [6..9] ↑ 1 [5..9] ↑ 1
  - Half times of 5 is 0 and half 1
- Some systems use Number() for floating
- *Money* or C*urrency* data are numeric data with a currency sign: $, £, €, ¥

SQL Character Strings

- A character string is a sequence of *printable* chars
- In SQL, a character string is denoted by enclosing it in *single quotes*: 'Hello SQL'
- Character strings types
  - *Fixed length n*: CHAR(n) or CHARACTER(n)
  - *Varying length of maximum n*: VARCHAR(n) or CHAR VARYING (n) **-VARCHAR2(n) in Oracle**
  - The default value of n is 1, representing a single character. Also, CHAR or CHARACTER
  - CLOBS(Size): Character Large Objects [SQL99]
    - size specified in kilobytes (K), megabytes (M), or gigabytes (G)

SQL Character Strings

- Concatenation operator: ||
  - 'abc' || 'XYZ' results in 'abcXYZ'
- Foreign-language characters (ISO-defined chars):
  - NATIONAL CHAR(n)
  - NATIONAL VARCHAR(n)

SQL Bit Strings

- Bit strings are sequences of binary digits, or bits
- In SQL, a bit string is denoted by enclosing it in *single quotes*: B'0101100110'
- Bit String types
  - *Fixed length n*: BIT(n)
  - *Varying length of maximum n*: VARBIT(n) or BIT VARYING (n)
- The default value for n is 1
  - BLOBS (size): Binary Large Objects [SQL99]
  - size specified in kilobytes (K), megabytes (M), or gigabytes (G)

SQL Temporal Data

- DATE data type
- TIME and TIMESTAMP data types
- INTERVAL data type.
  - INTERVAL data type represents periods of time

Date and Time

- DATE (10 positions) stores calendar values representing YEAR, MONTH, and DAY: **YYYY-MM-DD**
- TIME defines HOURS, MINUTES, and SECONDS in a twenty-four-hour notation: **HH:MM:SS**
- TIME(i) defines *i* additional decimal fractions of seconds: **HH:MM:SS:ddd...d**
- TIME WITH TIME ZONE includes the displacement [+13:00 to -12:59] from standard universal time zone: **HH:MM:SS{+/-}hh:mm**
  - *hh* are the two digits for the TIMEZONE_HOUR and *mm* the two digits for TIMEZONE_MINUTE
- TIMESTAMP represents a complete date and time with 6 fractions of seconds and optional time zone.

DATETIME Type & Oracle DATE

- DATETIME is not a valid ANSI SQL type
- Not supported by Oracle - Oracle DATE = ANSI TIMESTAMP
- MySQL DATETIME is used as a TIMESTAMP
  - MySQL DATETIME supported range is '1000-01-01 00:00:00' to '9999-12-31 23:59:59'
  - MySQL TIMESTAMP supported range is '1970-01-01 00:00:01' UTC to '2038-01-19 03:14:07' UTC
    - has varying properties, depending on the MySQL version and the SQL mode the server is running in.
- Transarc-SQL: No TIMESTAMP
  - DATETIME: 1753-01-01 to 9999-12-31[hh:mm:ss:nnn]
  - DATETIME2: 0001-01-01 00:00:00.0000000 to 9999-12-31 23:59:59.9999999

Functions on Dates

- All systems provide functions under different names
  - for constructing a date from strings or integers
  - for extracting out the month, day, or year from a date
  - for displaying dates in different ways
- Examples,
  - CAST(string AS DATE) [SQL2: CAST(<value> AS <type>)]
    e.g., CAST('2002-02-18' AS DATE)
  - MAKEDATE (int year, int month, int day) or DATE (int year, int month, int day)
    e.g., MAKEDATE(1999, 12, 31)
  - EXTRACT (MONTH/DAY/YEAR FROM <date>) [SQL3]
  - YEAR(<date>), MONTH(<date>), DAY(<date>)

Constructing Date Functions in Oracle

Oracle	Returns
TO_CHAR(d,format)	character-string equivalent of *d* based on *format*
TO_DATE(s,format)	date corresponding to *s* based on *format*
TO_TIMESTAMP(s, format)	date corresponding to *s* based on *format*

Examples:

- TO_DATE('2011-FEB-18', 'YYYY-MON-DD')
- TO_DATE('02182011' , 'MMDDYYYY')
- TO_CHAR(mydate, DY) → returns sun, mon, tue, wed, thu, fri, sat

Format	Description
MM	Month number
MON	3-letter abbreviation of month
MONTH	Fully spelled-out month
D	Number of days in the week
DD	Number of days in the month
DDD	Number of days in the year
DY	3-letter abbreviation of day of week
DAY	Fully spelled-out day of week
Y, YY, YYY, YYYY	Last 1, 2, 3 or 4 digits of year
HH12, HH24	Hours of the day (1-12 or 0-23)
MI	Minutes of hour
SS	Seconds of minute
AM	Display AM or PM depending on time

Resolving Spec Ambiguity

- TO_DATE('02182011' , 'MMDDYYYY')
- It parses to the longest keyword.
- Examples:
  - 'DYY' = DY and Y
    TO_DATE('WED7', 'DYY') = 01-FEB-17
  - 'DDDYYYY' = DDD and YYYY
    TO_DATE('3232017', 'DDDYYYY') = 19-NOV-17
  - 'DYYY' = DY and YY
    TO_DATE('WED17', 'DYYY') = 01-FEB-17

Example of Date Functions

Oracle	SQLServer	MySQL	Returns
SYSDATE	CURRENT_TIMESTAMP GETDATE()	CURRENT_TIMESTAMP	current date and time on the server
ADD_MONTHS(d,n)	DATEADD(datepart,n,d)	ERVAL n u) ERVAL n u)	*d + n* *d – n* *n* months after d
MONTHS_BETWEEN(d2,d1)	DATEDIFF(datepart,d1,d2)		*d2 – d1* *d2 – d1* in months
NEXT_DAY(d, weekday)			next date after *d* that falls on weekday
LAST_DAY(d)			last day of the month to which *d* belongs

datepart:
year,yy,yyyy,
quarter,qq,q,
month,mm,m,
dayofyear,dy,y,
day,dd,d,
week,wk,ww,
hour,hh,
minute,mi,n,
second,ss,s,
millisecond,ms

Example of Date Functions

Oracle	SQLServer	MySQL	Returns
SYSDATE	CURRENT_TIMESTAMP GETDATE()	CURRENT_TIMESTAMP SYSDATE() NOW()	
ADD_MONTHS(d,n)	DATEADD(datepart,n,d)	DATE_ADD(d,INTERVAL n u) DATE_SUB(d,INTERVAL n u)	
MONTHS_BETWEEN(d2,d1)	DATEDIFF(datepart,d1,d2)		
NEXT_DAY(d, weekday)			
LAST_DAY(d)			

u (units):
SECOND
MINUTE
HOUR
DAY
MONTH
YEAR
DAY_HOUR
DAY_MINUTE
DAY_SECOND
HOUR_MINUTE
HOUR_SECOND
MINUTE_SECOND
YEAR_MONTH

Postgres Functions on Dates

Function	Return Type	Description
age(timestamp, timestamp)	interval	Subtract arguments, producing a "symbolic" result that uses years and months
age(timestamp)	interval	Subtract from current_date (at midnight)
clock_timestamp()	timestamp with time zone	Current date and time (changes during statement execution); see Section 9.9.4
current_date	date	Current date; see Section 9.9.4
current_time	time with time zone	Current time of day; see Section 9.9.4
current_timestamp	timestamp with time zone	Current date and time (start of current transaction); see Section 9.9.4
date_part(text, timestamp)	double precision	Get subfield (equivalent to extract); see Section 9.9.1
date_part(text, interval)	double precision	Get subfield (equivalent to extract); see Section 9.9.1
date_trunc(text, timestamp)	timestamp	Truncate to specified precision; see also Section 9.9.2
extract(field from timestamp)	double precision	Get subfield; see Section 9.9.1
extract(field from interval)	double precision	Get subfield; see Section 9.9.1
isfinite(date)	boolean	Test for finite date (not +/-infinity)
isfinite(timestamp)	boolean	Test for finite time stamp (not +/-infinity)
isfinite(interval)	boolean	Test for finite interval
justify_days(interval)	interval	Adjust interval so 30-day time periods are represented as months
justify_hours(interval)	interval	Adjust interval so 24-hour time periods are represented as days
justify_interval(interval)	interval	Adjust interval using justify_days and justify_hours, with additional sign adjustments
localtime	time	Current time of day; see Section 9.9.4
localtimestamp	timestamp	Current date and time (start of current transaction); see Section 9.9.4
now()	timestamp with time zone	Current date and time (start of current transaction); see Section 9.9.4
statement_timestamp()	timestamp with time zone	Current date and time (start of current statement); see Section 9.9.4
timeofday()	text	Current date and time (like clock_timestamp, but as a text string); see Section 9.9.4
transaction_timestamp()	timestamp with time zone	Current date and time (start of current transaction); see Section 9.9.4

Example Postgres Functions on Dates

Example	Result
age(timestamp '2001-04-10', timestamp '1957-06-13')	43 years 9 mons 27 days
age(timestamp '1957-06-13')	43 years 8 mons 3 days
date_part('hour', timestamp '2001-02-16 20:38:40')	20
date_part('month', interval '2 years 3 months')	3
date_trunc('hour', timestamp '2001-02-16 20:38:40')	2001-02-16 20:00:00
extract(hour from timestamp '2001-02-16 20:38:40')	20
extract(month from interval '2 years 3 months')	3
isfinite(date '2001-02-16')	true
isfinite(timestamp '2001-02-16 21:28:30')	true
isfinite(interval '4 hours')	true
justify_days(interval '35 days')	1 mon 5 days
justify_hours(interval '27 hours')	1 day 03:00:00
justify_interval(interval '1 mon -1 hour')	29 days 23:00:00

Operations on Dates

- Datetime (+ or -) Interval = Datetime
- Datetime - Datetime = Interval
- Interval (* or /) Number = Interval
- Interval (+ or -) Interval = Interval

- Examples (ANSI SQL):
  - (CURRENT_DATE + INTERVAL '1' MONTH)
  - (CURRENT_DATE - INTERVAL '18' DAY)
  - (CURRENT_DATE – BirthDate)

Intervals

- An interval results when two dates are subtracted. E.g., AdmitDate – DischargeDate
- Two interval data types: **Year-Month** & **Day-Time**
- Format: INTERVAL start-field(p) [TO end-field(fs)]
  - p is the precision (default is 2 digits)
  - fs is the fractional second precision, which is only applicable to DAY/TIME (default is 6 digits)
- Year-Month intervals:
  - INTERVAL YEAR, INTERVAL YEAR(p), INTERVAL MONTH, INTERVAL MONTH(p), INTERVAL YEAR TO MONTH, INTERVAL YEAR(p) TO MONTH
  - E.g., INTERVAL YEAR (2) to MONTH could be [0-0, 99-11]

Intervals…

- DAY-TIME intervals: the fields can be a contiguous selection from DAY, HOUR, MINUTE, SECOND
- E.g.,
  - INTERVAL DAY TO HOUR
    - [0:0, 99:23] (day:hours)
  - INTERVAL DAY(1) TO HOUR
    - [0:0, 9:23] (days:hours)
  - INTERVAL DAY TO MINUTE
    - [0:0:0, 99:23:59] (days:hours:minutes)
  - INTERVAL SECOND(8)
  - INTERVAL DAY(5) to SECOND(10)
  - INTERVAL MINUTE(3) to SECOND

Intervals…

Operator	Example	Result
+	date '2001-09-28' + integer '7'	date '2001-10-05'
+	date '2001-09-28' + interval '1 hour'	timestamp '2001-09-28 01:00:00'
+	date '2001-09-28' + time '03:00'	timestamp '2001-09-28 03:00:00'
+	interval '1 day' + interval '1 hour'	interval '1 day 01:00:00'
+	timestamp '2001-09-28 01:00' + interval '23 hours'	timestamp '2001-09-29 00:00:00'
+	time '01:00' + interval '3 hours'	time '04:00:00'
-	- interval '23 hours'	interval '-23:00:00'
-	date '2001-10-01' - date '2001-09-28'	integer '3' (days)
-	date '2001-10-01' - integer '7'	date '2001-09-24'
-	date '2001-09-28' - interval '1 hour'	timestamp '2001-09-27 23:00:00'
-	time '05:00' - time '03:00'	interval '02:00:00'
-	time '05:00' - interval '2 hours'	time '03:00:00'
-	timestamp '2001-09-28 23:00' - interval '23 hours'	timestamp '2001-09-28 00:00:00'
-	interval '1 day' - interval '1 hour'	interval '1 day -01:00:00'
-	timestamp '2001-09-29 03:00' - timestamp '2001-09-27 12:00'	interval '1 day 15:00:00'
*	900 * interval '1 second'	interval '00:15:00'
*	21 * interval '1 day'	interval '21 days'
*	double precision '3.5' * interval '1 hour'	interval '03:30:00'
/	interval '1 hour' / double precision '1.5'	interval '00:40:00'

Quick Example.. Student Table

SID	*Name*	*PSID*	*Age*	*GPA*
546007	Jones	689065	18	3.4
546100	Smith	987452	18	3.2
546500	Smith	342875	19	3.8

```
CREATE TABLE Student
(  sid CHAR(20),
   name CHAR(20),
   psid INTEGER,
   age INTEGER,
   gpa REAL,
   Constraint Student_PK
      PRIMARY KEY (sid) );
```

```
CREATE TABLE Student
(  sid CHAR(20)
      Constraint Student_PK
      PRIMARY KEY ,
   name CHAR(20),
   psid INTEGER,
   age INTEGER,
   gpa REAL );
```


Table Schema Storing Option

```
CREATE TABLE  STUDENT
(  SID  INTEGER,
   Name CHAR(20),
   PSID INTEGER NOT NULL,
   AGE  INTEGER,
GPA  REAL,
CONSTRAINT STUDENT_PK
   PRIMARY KEY (SID),
CONSTRAINT STUDENT_AK
   UNIQUE (PSID))
.  TABLESPACE                          -- In postgres
   IS TABLESPACE {tablespace | users}; -- In Oracle
   ON {filegroup | DEFAULT};           -- In SQLServer
```

Table Schema (MySQL)

```
CREATE TABLE STUDENT
( SID INTEGER,
  Name CHAR(20),
  PSID INTEGER NOT NULL,
  AGE INTEGER,
  GPA REAL,
  CONSTRAINT STUDENT_PK
    PRIMARY KEY (SID),
  CONSTRAINT STUDENT_AK
    UNIQUE (PSID)
) Engine = INNODB;      -- Required in MySQL to support FK
```

Other options: ARCHIVE, CSV, HEAP, Memory, myisam, ndbcluster

Table Schema (DB2)

```
CREATE TABLE STUDENT
( SID INTEGER NOT NULL, -- REQUIRED for PK,
  Name CHAR(20),
  PSID INTEGER NOT NULL, -- REQUIRED for AK,
  AGE INTEGER,
  GPA REAL,
  CONSTRAINT STUDENT_PK
    PRIMARY KEY (SID),
  CONSTRAINT STUDENT_AK
    UNIQUE (PSID)
) IN userspace1;
```


Discarding a Table

- **DROP TABLE** <db-name> [**RESTRICT** | ***CASCADE***];
  - Restrict: removes the table it is not referenced
  - *Cascade*: removes the table and all references to it
- Oracle Example:
  - **DROP TABLE** Student **CASCADE CONSTRAINTS;**
  - **DROP TABLE** Student **PURGE;**
  - **PURGE RECYCLEBIN;**

Creating Domains

- Domain is a schema component for defining datatype macros
  - Basic datatype
  - DEFAULT value
  - CHECK (validity conditions)
- Examples:

```
CREATE DOMAIN sectno_dom AS SMALLINT;

CREATE DOMAIN gpa_dom DECIMAL (3,2) DEFAULT 0.00;

CREATE DOMAIN ssn_dom CHAR(11)
  CONSTRAINT ssn_dom_value
  CHECK (VALUE BETWEEN '000-00-0000' AND '999-99-9999');
```

Removing a Domain

- **DROP DOMAIN** <dname> [**RESTRICT** | ***CASCADE***];
  - *Restrict*: removes the domain it is not used
  - *Cascade*: removes the domain and replaces all its uses to its underlying datatype
- Example:
  - **CREATE DOMAIN** gender_dom **AS** CHAR(1)
    CONSTRAINT gender_dom_value
    CHECK ((VALUE IN ('F', 'f', 'M', 'm')) OR (VALUE IS NULL));
  - **DROP DOMAIN** gender_dom **CASCADE**;

Example Schema

```
CREATE TABLE Student (
   Sid INTEGER,  Name CHAR(20),
   Age INTEGER,
   GPA REAL,
   Major CHAR(10),

   CONSTRAINT STUDENT_PK
      PRIMARY KEY  (Sid));
```


CHECK Constraint and DOMAIN

```
CREATE DOMAIN M_Code AS CHAR(10)
   CHECK (Value IN ('CS', 'Film', 'History'));

CREATE TABLE Student (
   Sid INTEGER,  Name CHAR(20),
   Age INTEGER,
   GPA REAL,
   Major M_Code,

   CONSTRAINT STUDENT_PK
      PRIMARY KEY  (Sid));
```


Example… Minor &Constraints

```
CREATE DOMAIN M_Code AS CHAR(10)
   CHECK (value IN ('CS' ,'Film', 'History'));

CREATE TABLE Student (
   Sid INTEGER,  Name CHAR(20),
   Age INTEGER,
   GPA REAL,
   Major M_Code,
   Minor …,  what constraints are needed for Minor?
   CONSTRAINT STUDENT_PK
      PRIMARY KEY  (Sid));
```

IC1: Minor IN …
IC2: Minor ≠ Major

Example: attribute-based

```
CREATE DOMAIN M_Code AS CHAR(10)
   CHECK (value IN ('CS', 'Film', 'History'));

CREATE TABLE Student (
   Sid INTEGER, Name CHAR(20),
   Age INTEGER,
   GPA REAL,
   Major M_Code,
   Minor M_Code,
   CONSTRAINT STUDENT_PK
    PRIMARY KEY (Sid));
```

IC1: attribute-based

Example: attribute- and tuple-based

```
CREATE DOMAIN M_Code AS CHAR(10)
  CHECK (value IN ('CS', 'Film', 'History'));

CREATE TABLE Student (
   Sid INTEGER, Name CHAR(20),
   Age INTEGER,
   GPA REAL,
   Major M_Code,
   Minor M_Code,
    CHECK (Major != Minor),
   CONSTRAINT STUDENT_PK
    PRIMARY KEY (Sid));
```

IC1: attribute-based

IC2: tuple-based

Example: attribute- and tuple-based

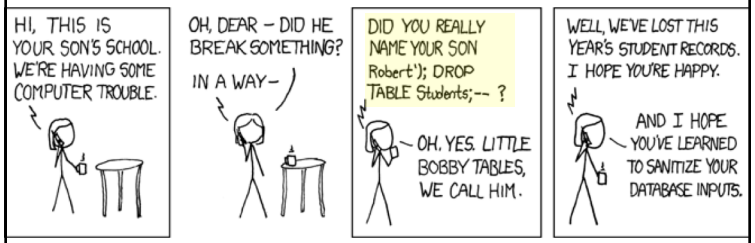
```
CREATE DOMAIN M_Code AS CHAR(10)
  CHECK (value IN ('CS', 'Film', 'History'));

CREATE TABLE Student (
   Sid INTEGER, Name CHAR(20),
   Age INTEGER,
   GPA REAL,
   Major M_Code,
   Minor M_Code,
   CONSTRAINT STUDENT_Major_Minor
    CHECK (Major != Minor),
   CONSTRAINT STUDENT_PK PRIMARY KEY (Sid));
```

IC1: attribute-based

IC2: tuple-based

Be careful with your database inputs ☺



CHECK Constraint Major in-line

```
CREATE TABLE Student (
   Sid INTEGER, Name CHAR(20),
   Age INTEGER,
   GPA REAL,
   Major CHAR(10)
       CHECK (Major IN ('CS', 'Film', 'History')),

   CONSTRAINT STUDENT_PK
     PRIMARY KEY (Sid));
```


CHECK Constraint Minor in-line

```
CREATE TABLE Student (
   Sid INTEGER, Name CHAR(20),
   Age INTEGER,
   GPA REAL,
   Major CHAR(10)
       CHECK (Major IN ('CS', 'Film', 'History')),
   Minor CHAR(10)
       CHECK ((Minor IN ('CS', 'Film', 'History')
                AND (Major != Minor)),
   CONSTRAINT STUDENT_PK
     PRIMARY KEY (Sid));
```


Specify Constraints Separately

```
CREATE TABLE Student (
   Sid INTEGER, Name CHAR(20),
   Age INTEGER, GPA REAL,
   Major CHAR(10), Minor CHAR(10),
   CONSTRAINT STUDENT_PK
     PRIMARY KEY (Sid),
   CONSTRAINT STUDENT_Major
     CHECK (Major IN ('CS', 'Film', 'History')),
   CONSTRAINT STUDENT_Minor
     CHECK (Minor IN ('CS', 'Film', 'History')),
   CONSTRAINT STUDENT_Major_Minor
     CHECK (Major != Minor));
```


CHECK Constraint 2

No Create Domain in Oracle, so …

```
CREATE TABLE Student (
   Sid INTEGER, Name CHAR(20),
   Age INTEGER,
   GPA REAL
       CHECK (GPA>=0.0 AND GPA <= 4.0);
   Major CHAR(10)
       CHECK (Major IN ('CS', 'Film', 'History'));
   CONSTRAINT STUDENT_PK
     PRIMARY KEY (Sid));
```

Constraint Management

```
ALTER TABLE Student DROP
    CONSTRAINT STUDENT_Major_Minor;
```

```
ALTER TABLE Student ADD
    CONSTRAINT STUDENT_Major_Minor
      CHECK (Major != Minor);
```

- To modify a constraint:
  - drop it first then add a new one

Table Schema Evolution

- The ALTER command allows to alter the domain of an attribute, add and drop an attribute or constraint
- ALTER TABLE <table-name> ALTER [COLUMN]
  - Domain change of an attribute
    E.g., ALTER TABLE Student
    ALTER QPA DECIMAL(4,2);
    – Warning: Type Narrowing is possible as in C/C++
  - Set or drop the default value of an attribute
    E.g.1, ALTER TABLE SECTION
    ALTER COLUMN Head DROP DEFAULT;
    E.g.2, ALTER TABLE SECTION
    ALTER Head SET DEFAULT NULL;

Table Schema Evolution in Oracle

- ALTER TABLE <table-name> MODIFY [COLUMN]
  - Domain change of an attribute
    E.g., ALTER TABLE Student
    MODIFY QPA DECIMAL(4,2);
  - Set or drop the default value of an attribute
    E.g.1, ALTER TABLE SECTION
    MODIFY COLUMN Head DROP DEFAULT;
    E.g.2, ALTER TABLE SECTION
    MODIFY Head SET DEFAULT NULL;

Modifying a Table Schema…

- ALTER TABLE <table-name> ADD [COLUMN]
  ALTER TABLE LIBRARIAN
  ADD Gender gender_dom;
- ALTER TABLE <tbl-name> DROP [COLUMN]… [Option]
  - CASCADE option
    ALTER TABLE SECTION
    DROP COLUMN Head CASCADE;
  - RESTRICT option (default)
    ALTER TABLE SECTION
    DROP Head RESTRICT;