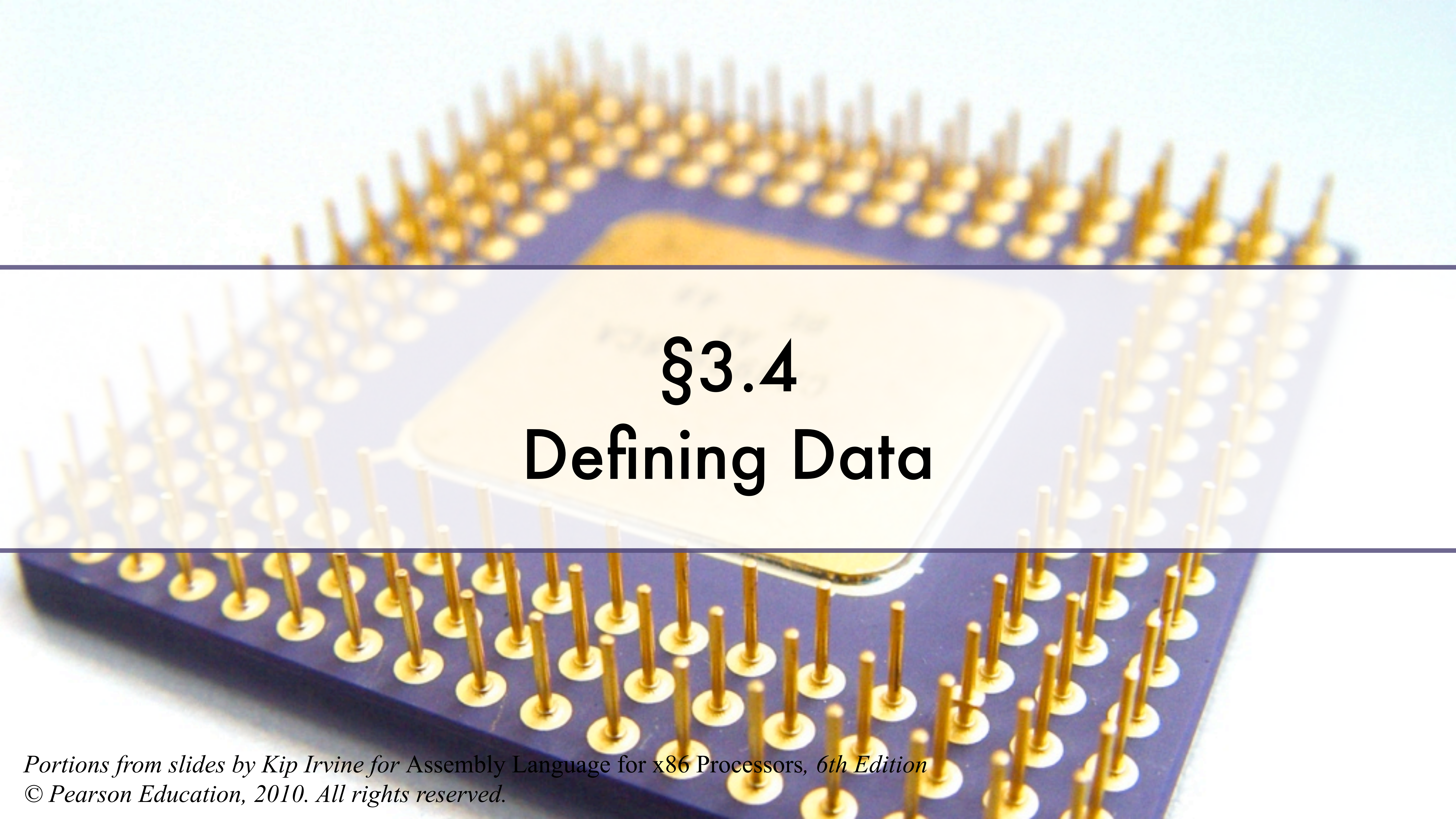
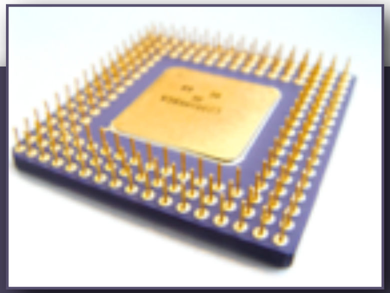


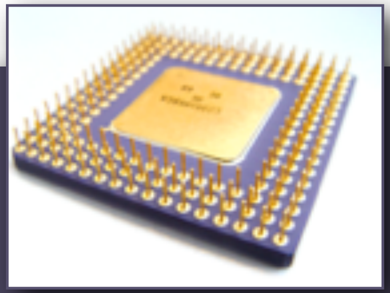
§3.4
Defining Data

Intrinsic Data Types



- BYTE, SBYTE – 8-bit unsigned, signed integer
- WORD, SWORD – 16-bit unsigned, signed integer
- DWORD, SDWORD – 32-bit unsigned, signed integer
- QWORD – 64-bit integer
- REAL4 – 4-byte IEEE short real (floating point)
- REAL8 – 8-byte IEEE long real (floating point)
- REAL10 – 10-byte IEEE extended real (floating point)

Data Definition Statement



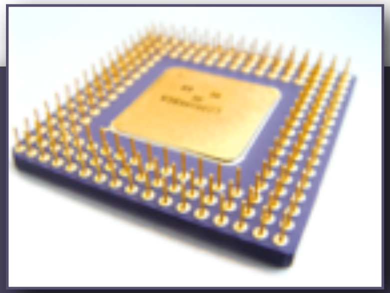
- A data definition statement sets aside storage in memory for a variable.
- May optionally assign a name (label) to the data
- Syntax:

[*name*] *directive initializer* [,*initializer*] . . .

```
value1 BYTE 10
```

- All initializers become binary data in memory

Defining BYTE & SBYTE Data



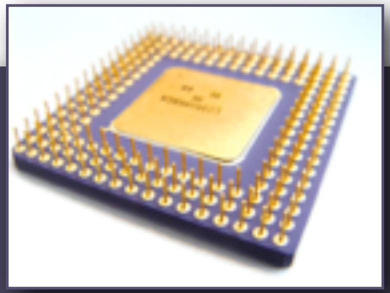
Each of the following defines a single byte of storage:

```
value1 BYTE 'A'                 ; character constant
value2 BYTE 0                   ; smallest unsigned byte
value3 BYTE 255                 ; largest unsigned byte
value4 SBYTE -128               ; smallest signed byte
value5 SBYTE +127               ; largest signed byte
value6 BYTE ?                   ; uninitialized byte
```

MASM does not prevent you from initializing a BYTE with a negative value, but it's considered poor style.

If you declare a SBYTE variable, the debugger will display its value in decimal with a leading sign.

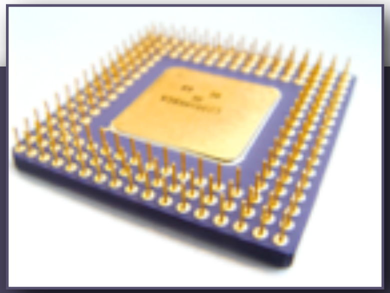
Defining Byte Arrays



Examples that use multiple initializers:

```
list1 BYTE 10,20,30,40
list2 BYTE 10,20,30,40
      BYTE 50,60,70,80
      BYTE 81,82,83,84
list3 BYTE ?,32,41h,00100010b
list4 BYTE 0Ah,20h,‘A’,22h
```

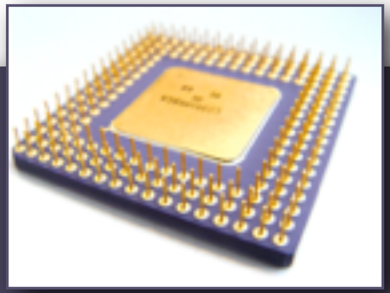
Defining Strings (1 of 2)



- A string is implemented as an array of bytes
  - For convenience, it is usually enclosed in quotation marks
  - It often will be null-terminated
- Examples:

```
str1 BYTE "Enter your name",0
str2 BYTE 'Error: halting program',0
str3 BYTE 'A','E','I','O','U'
greeting  BYTE "Welcome to the Encryption Demo program "
          BYTE "created by Kip Irvine.",0
```

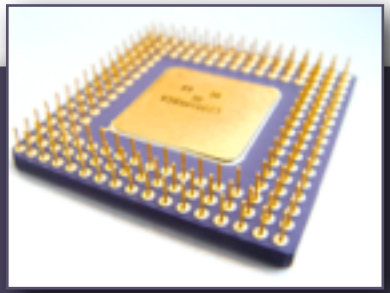
Defining Strings (2 of 2)



- To continue a single string across multiple lines, end each line with a comma:

```
menu BYTE "Checking Account",0dh,0ah,0dh,0ah,
    "1. Create a new account",0dh,0ah,
    "2. Open an existing account",0dh,0ah,
    "3. Credit the account",0dh,0ah,
    "4. Debit the account",0dh,0ah,
    "5. Exit",0ah,0ah,
    "Choice> ",0
```

Using the DUP Operator

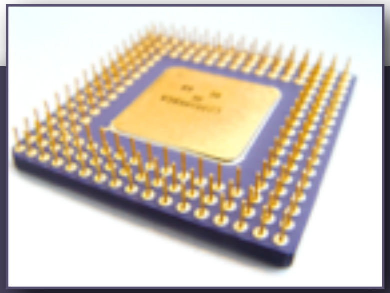


- Use DUP to allocate (create space for) an array or string. Syntax:
  counter DUP (*argument*)

Counter and *argument* must be constants or constant expressions

```
var1 BYTE 20 DUP(0)            ; 20 bytes, all equal to zero
var2 BYTE 20 DUP(?)            ; 20 bytes, uninitialized
var3 BYTE 4 DUP("STACK")      ; 20 bytes: "STACKSTACKSTACKSTACK"
var4 BYTE 10,3 DUP(0),20       ; 5 bytes
```

Defining WORD & SWORD Data



- Define storage for 16-bit integers
  - single value or array (multiple values)

```
word1   WORD   65535            ; largest unsigned value
word2   SWORD -32768            ; smallest signed value
word3   WORD   ?                ; uninitialized, unsigned
word4   WORD   "AB"             ; double characters
myList WORD   1,2,3,4,5        ; array of words
array   WORD   5 DUP(?)         ; uninitialized array
```

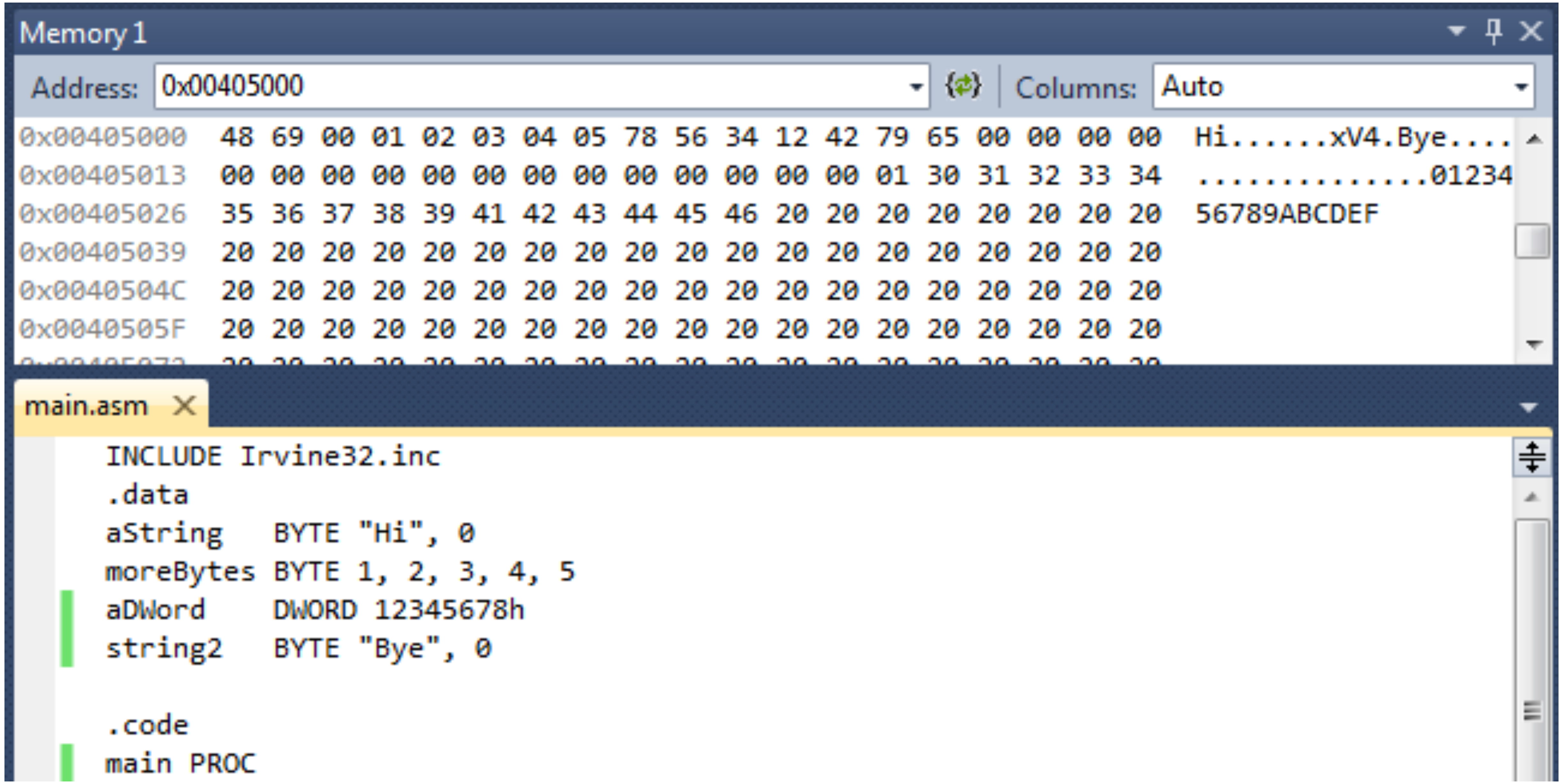
Defining DWORD & SDWORD Data

Storage definitions for signed and unsigned 32-bit integers:

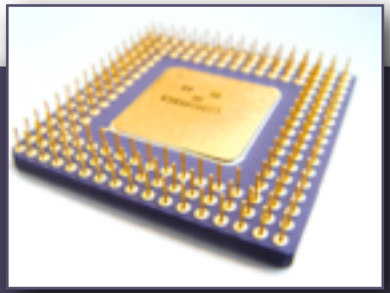
```
val1 DWORD  12345678h           ; unsigned
val2 SDWORD -2147483648         ; signed
val3 DWORD  20 DUP(?)           ; unsigned array
val4 SDWORD -3,-2,-1,0,1        ; signed array
```

VS Memory Window

- Recall from Lab 2 how to use the Memory Window in the Visual Studio debugger



Little Endian Order

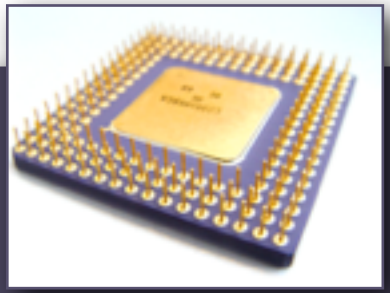


- General purpose registers store 32-bit values; memory stores bytes
- For all data types larger than a byte:
  - The ***l***east significant byte is stored in the ***l***owest memory address
  - This is called ***little endian*** byte ordering
- Example:

```
val1 DWORD 12345678h
```

78h	56h	34h	12h
0000	0001	0002	0003

Big Endian Order

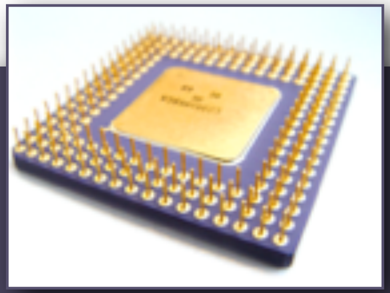


- **x86 processors use little endian byte ordering**, but...
- Some other processors use *big endian,* where 12345678h would be stored as

12h	34h	56h	78h
0000	0001	0002	0003

- Big endian is also called *network byte order*
  - The Internet Protocol (IP) and many other protocols transfer 16- and 32-bit values in big-endian order, i.e., the most significant byte is transmitted first

Using Data in Memory (1 of 2)

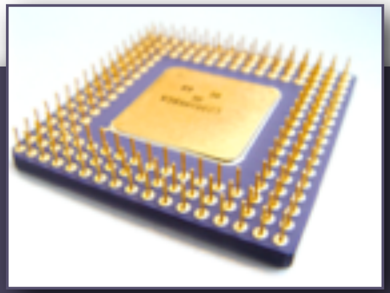


- You know two versions of the mov instruction:
  - `mov` *register*, *immediate* — `mov eax, 5`
  - `mov` *register*, *register* — `mov eax, ebx`
- You can also move data to and from memory:

```
.data
myVar   DWORD   135
```

  - `mov` *register*, *memory* — `mov eax, myVar`
  - `mov` *memory*, *register* — `mov myVar, ebx`
  - `mov` *memory*, *immediate* — `mov myVar, 9876`
  - `mov` *immediate*, *memory* — **Q.** Is this possible?

Using Data in Memory (2 of 2)



```
TITLE Add and Subtract, Version 2            (AddSub2.asm)
; This program adds and subtracts 32-bit unsigned
; integers and stores the sum in a variable.
INCLUDE Irvine32.inc
.data
val1 DWORD 10000h
val2 DWORD 40000h
val3 DWORD 20000h
finalVal DWORD ?
.code
main PROC
    mov eax,val1          ; start with 10000h - load from memory into register
    add eax,val2          ; add 40000h - load operand from memory
    sub eax,val3          ; subtract 20000h - load operand from memory
    mov finalVal,eax      ; store the result (30000h) - store result operand
    call DumpRegs         ; display the registers
    exit
main ENDP
END main
```

Declaring Unitialized Data

- Use the .data? directive to declare an uninitialized data segment:

```
.data?
```

- Within the segment, declare variables with "?" initializers:

```
smallArray DWORD 10 DUP(?)
```

Advantage: the program's EXE file size is reduced.