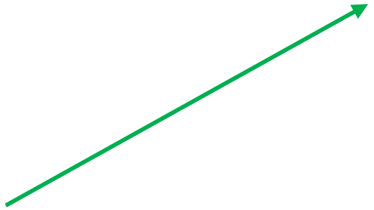
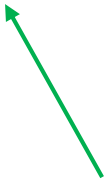
Compilation

The goal of a compiler

Translate from a **source language** to a **target language**



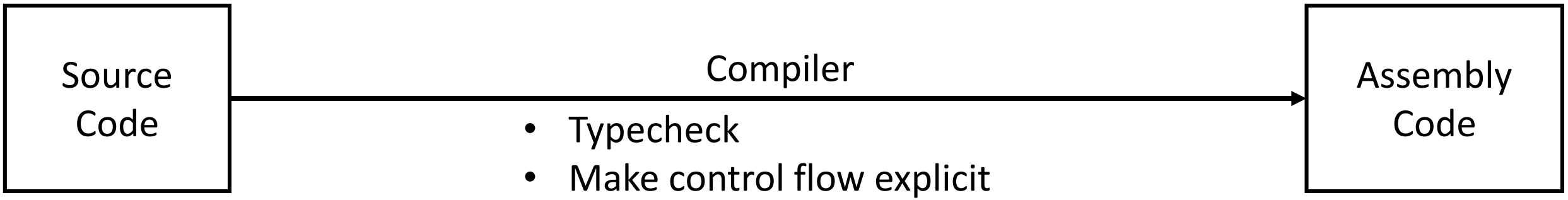


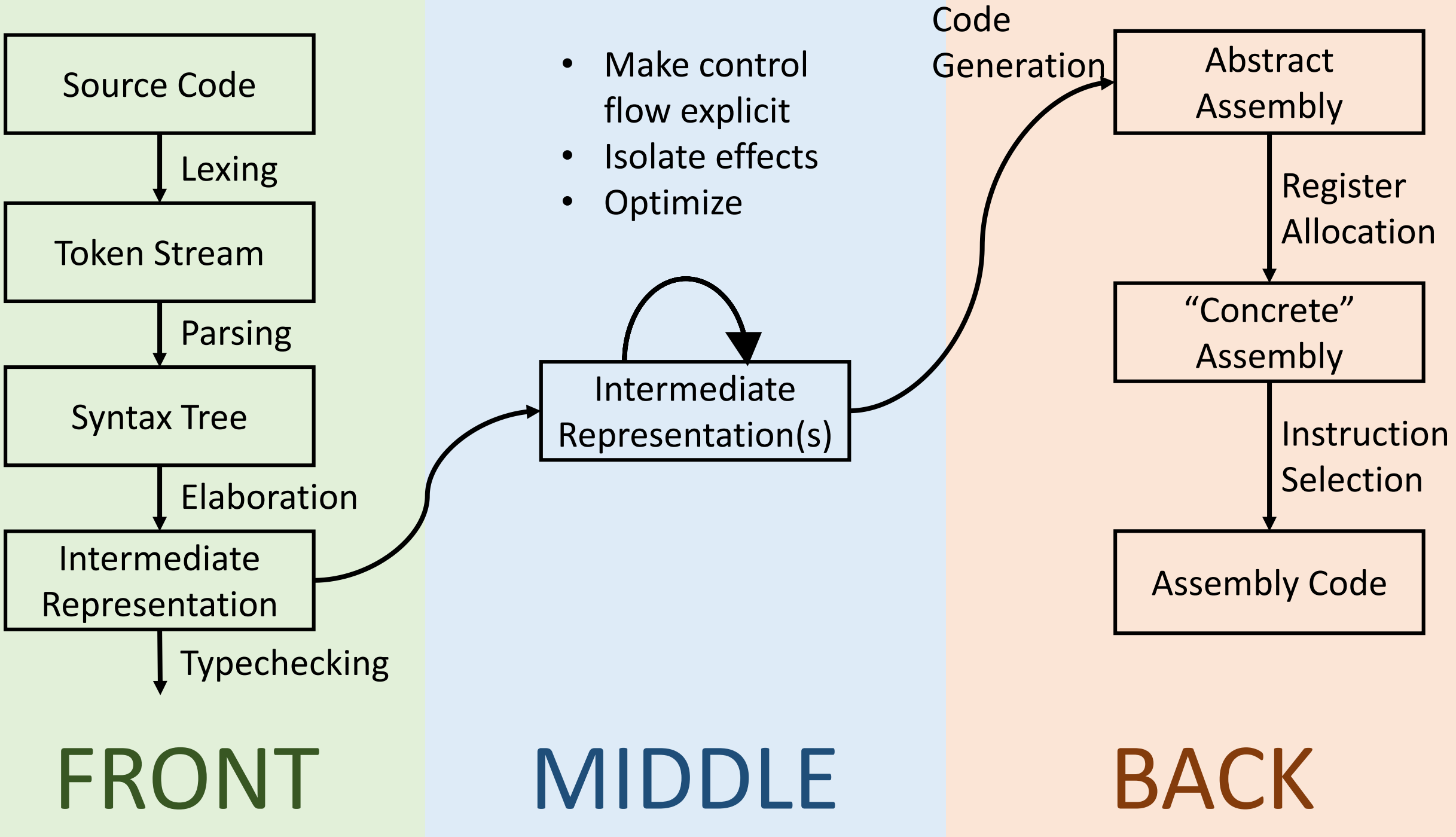
Usually a high-level language

- C
- SML
- Java
- Go
- Rust

Usually a low-level language

- X86 Assembly
- Java Bytecode
- C


Source Code
Compiler
Typecheck
Make control flow explicit
Flatten expressions
Optimize
Allocate variables to registers
Assembly Code


Source Code
Lexing
Token Stream
Parsing
Syntax Tree
Elaboration
Intermediate Representation
Typechecking
FRONT
Make control flow explicit
Isolate effects
Optimize
Intermediate Representation(s)
MIDDLE
Code Generation
Abstract Assembly
Register Allocation
"Concrete" Assembly
Instruction Selection
Assembly Code
BACK

Example Source Language: System C

Arithmetic Expression	$aexp$	::=	x	variable
			c	numerical constant
			$aexp$ `+` $aexp$	addition
			$aexp$ `-` $aexp$	subtraction
			$aexp$ `*` $aexp$	multiplication
			$aexp$ `/` $aexp$	division
Boolean Expression	$bexp$	::=	`true`	true constant
			`false`	false constant
			`!`$bexp$	logical negation
			$bexp$ `||` $bexp$	logical or
			$bexp$ `&&` $bexp$	logical and
			$aexp$ `==` $aexp$	equality
			$aexp$ `!=` $aexp$	inequality
			$aexp$ `<` $aexp$	less than
			$aexp$ `>` $aexp$	greater than
Command	cmd	::=	x `=` $aexp$`;`	assignment
			`if` $bexp$ `{` $cmds$ `}` `else` `{` $cmds$`}`	conditional
			`while` $bexp$ `{` $cmds$`}`	loop
			`return` $aexp$`;`	return
Program	$program$	::=	`main` $(params)$ `{` $cmds$`}`	

Example (Abstract) Assembly Language

Operand	*oper*	::=	x	variable
			c	constant
Instruction	*instruction*	::=	ℓ :	label
			$x \leftarrow oper$	mov
			$x \leftarrow oper + oper$	add
			$x \leftarrow oper - oper$	sub
			$x \leftarrow oper \times oper$	mul
			$x \leftarrow oper \div oper$	div
			$x \leftarrow oper = oper$	eq
			$x \leftarrow oper < oper$	lt
			`JUMP` ℓ	jump
			`IF` *oper* `THEN` ℓ `ELSE` ℓ	conditional jump
			`RET` *oper*	return
Program	*program*	::=	`main` $(params) = instructions$	

Notes that may be useful for the homework

- Code Generation (especially pages 1-6)
  http://www.cs.cmu.edu/~janh/courses/411/17/lec/02-instsel.pdf
- Intermediate representations (especially pages 4-7)
  http://www.cs.cmu.edu/~janh/courses/411/17/lec/11-irtrees.pdf

Take 15-411 (Compiler Design)