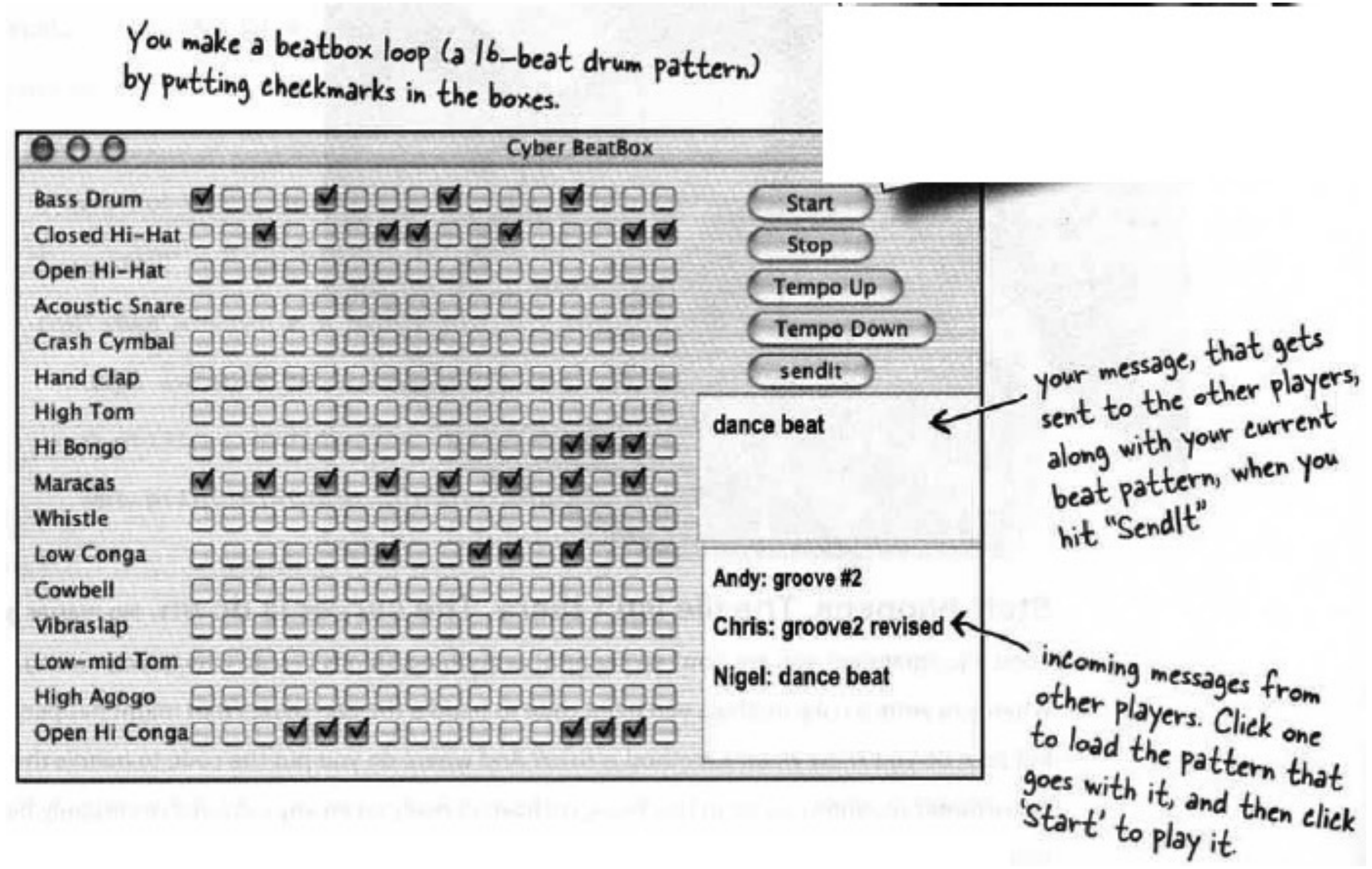
异常

An example



You make a beatbox loop (a 16-beat drum pattern) by putting checkmarks in the boxes.

Bass Drum	✓				✓				✓				✓			
Closed Hi-Hat			✓				✓	✓			✓				✓	✓
Open Hi-Hat																
Acoustic Snare																
Crash Cymbal																
Hand Clap																
High Tom																
Hi Bongo													✓	✓	✓	
Maracas	✓		✓		✓		✓		✓		✓		✓		✓	
Whistle																
Low Conga							✓			✓	✓		✓			
Cowbell																
Vibraslap																
Low-mid Tom																
High Agogo																
Open Hi Conga				✓	✓	✓							✓	✓	✓	

dance beat

your message, that gets sent to the other players, along with your current beat pattern, when you hit "SendIt"

Andy: groove #2

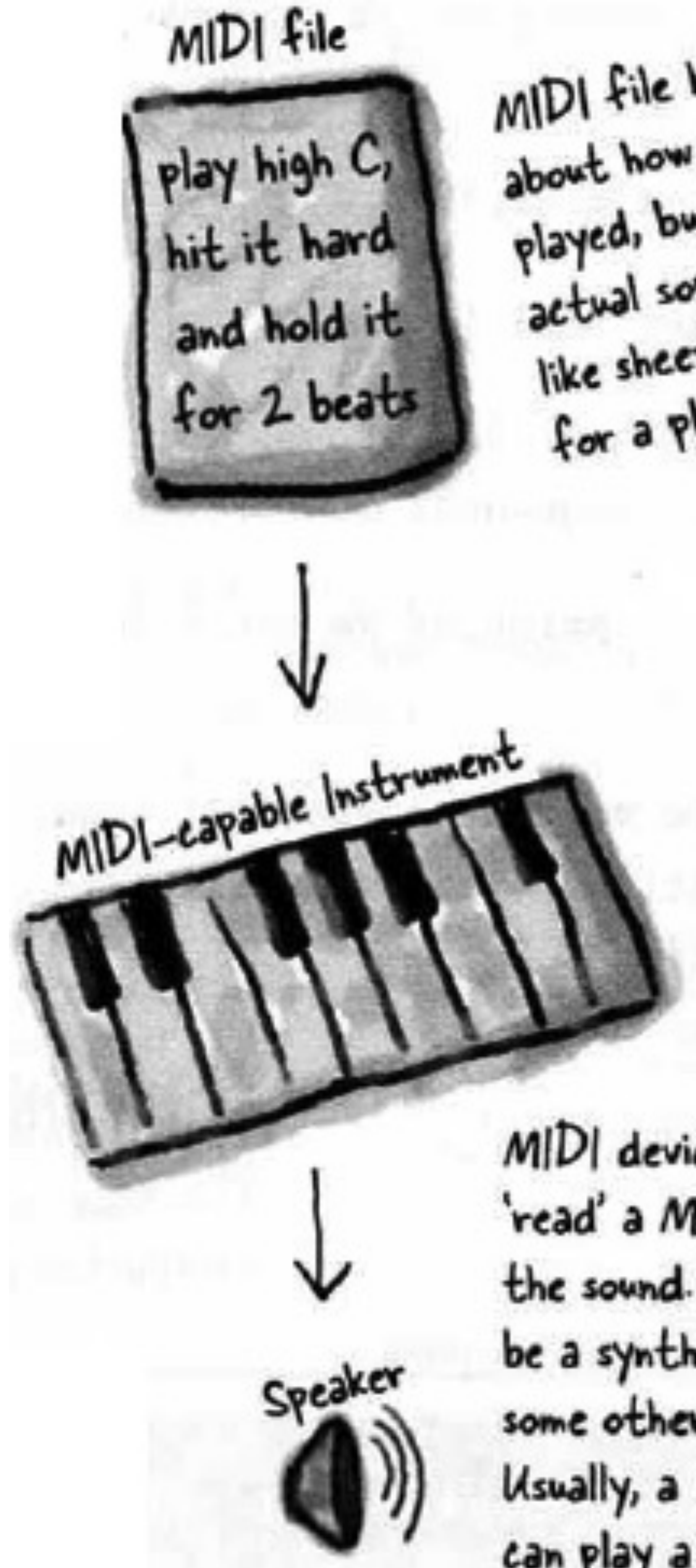
Chris: groove2 revised

Nigel: dance beat

incoming messages from other players. Click one to load the pattern that goes with it, and then click 'Start' to play it.

the JavaSound API

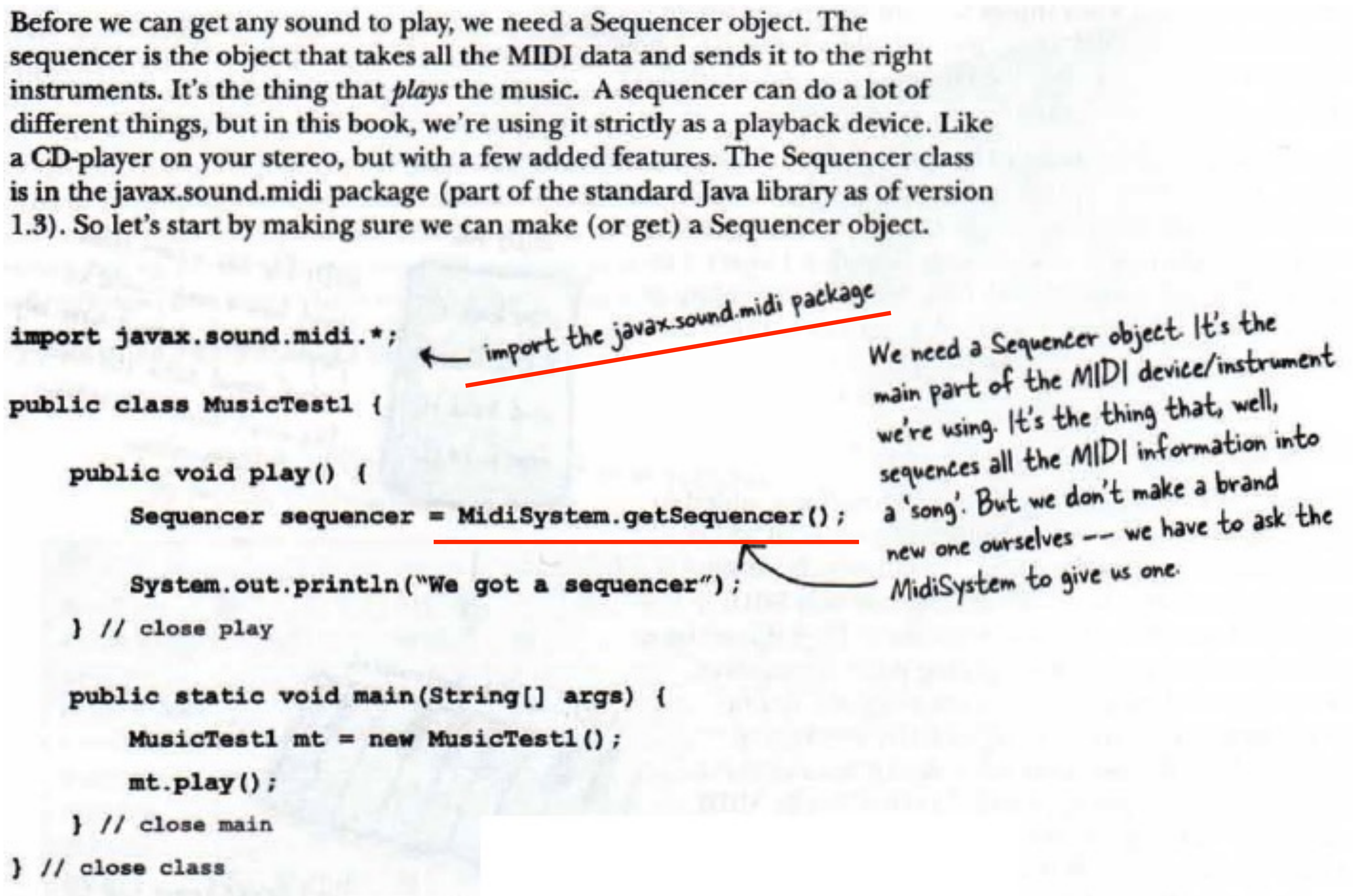
- JavaSound is a collection of classes and interfaces added to Java starting with version 1.3. These aren‘t special add-ons ，they’re part of the standard j2SE class library.
- MIDI stands for Musical instrument Digital Interface, and is a standard protocol for getting different kinds of electronic sound equipment to communicate.



MIDI file has information about how a song should be played, but it doesn't have any actual sound data. It's kind of like sheet music instructions for a player-piano.

MIDI device knows how to 'read' a MIDI file and play back the sound. The device might be a synthesizer keyboard or some other kind of instrument. Usually, a MIDI instrument can play a LOT of different sounds (piano, drums, violin, etc.), and all at the same time. So a MIDI file isn't like sheet music for just one musician in the band -- it can hold the parts for ALL the musicians playing a particular song.

First we need a Sequencer



Before we can get any sound to play, we need a Sequencer object. The sequencer is the object that takes all the MIDI data and sends it to the right instruments. It's the thing that *plays* the music. A sequencer can do a lot of different things, but in this book, we're using it strictly as a playback device. Like a CD-player on your stereo, but with a few added features. The Sequencer class is in the javax.sound.midi package (part of the standard Java library as of version 1.3). So let's start by making sure we can make (or get) a Sequencer object.

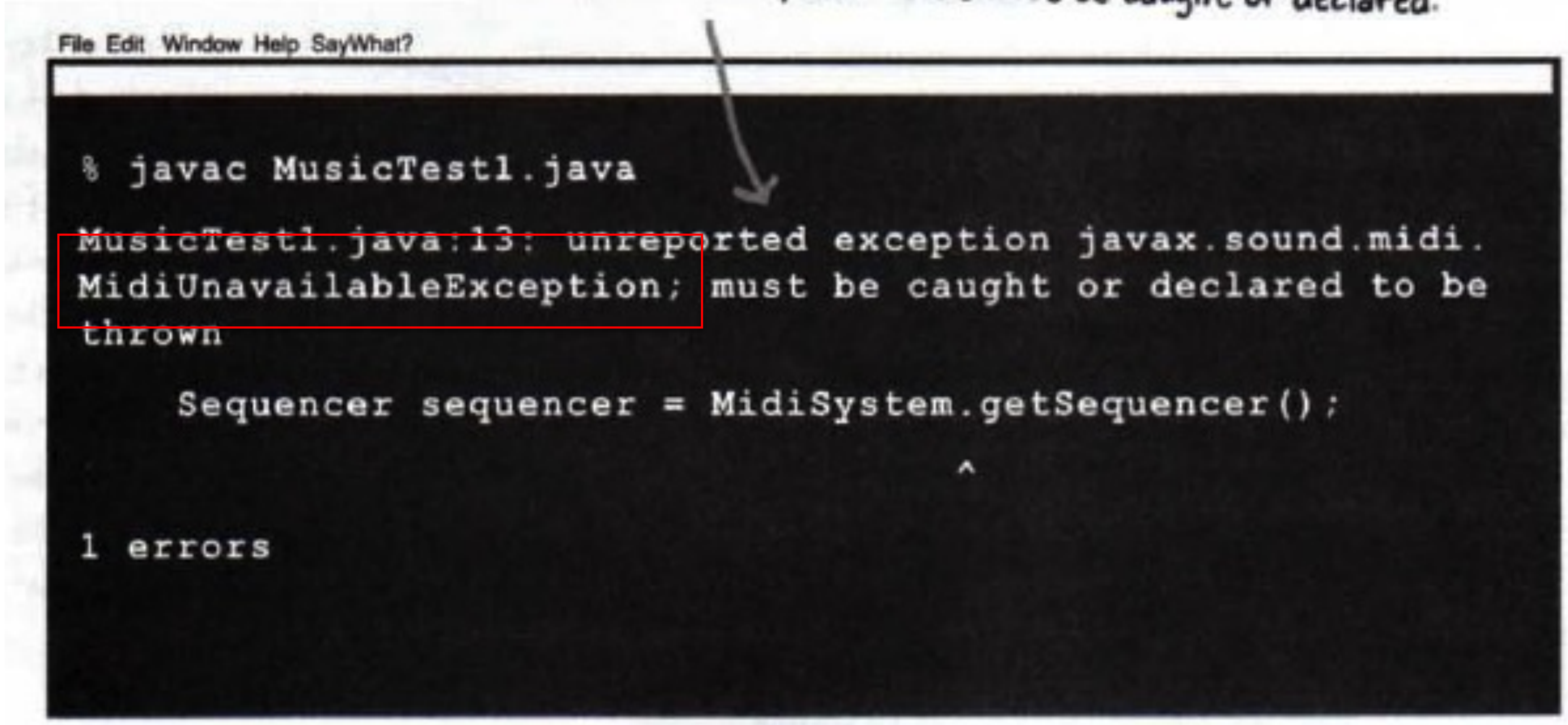
```
import javax.sound.midi.*;

public class MusicTest1 {

    public void play() {
        Sequencer sequencer = MidiSystem.getSequencer();

        System.out.println("We got a sequencer");
    } // close play

    public static void main(String[] args) {
        MusicTest1 mt = new MusicTest1();
        mt.play();
    } // close main
} // close class
```

← import the javax.sound.midi package

We need a Sequencer object. It's the main part of the MIDI device/instrument we're using. It's the thing that, well, sequences all the MIDI information into a 'song'. But we don't make a brand new one ourselves -- we have to ask the MidiSystem to give us one.

Something's wrong!

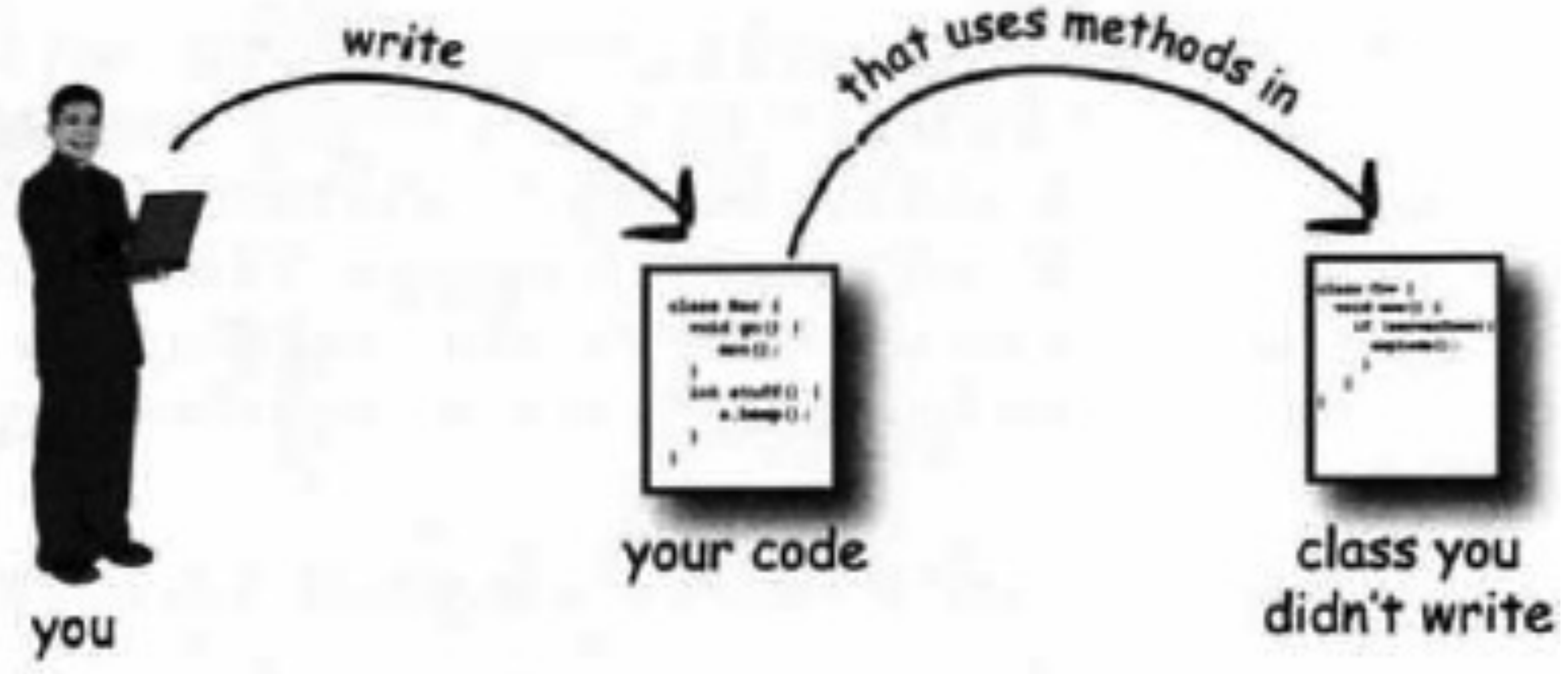
This code won't compile! The compiler says there's an 'unreported exception' that must be caught or declared.



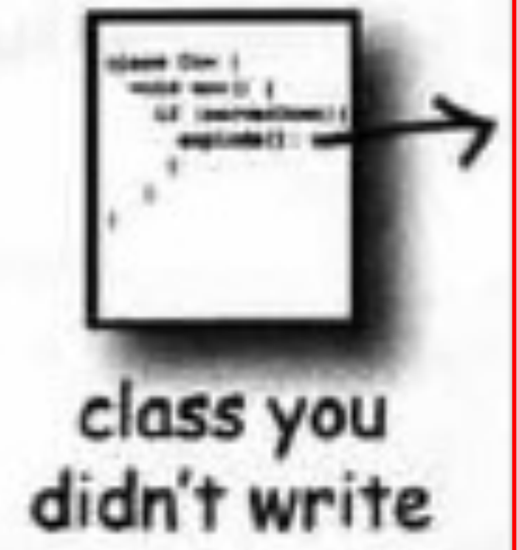
```
% javac MusicTest1.java

MusicTest1.java:13: unreported exception javax.sound.midi.
MidiUnavailableException; must be caught or declared to be
thrown

    Sequencer sequencer = MidiSystem.getSequencer();
                                    ^

1 errors
```

What happens when a method you want to call (probably in a class you didn't write) is risky?

1. **Let's say you want to call a method in a class that you didn't write.**

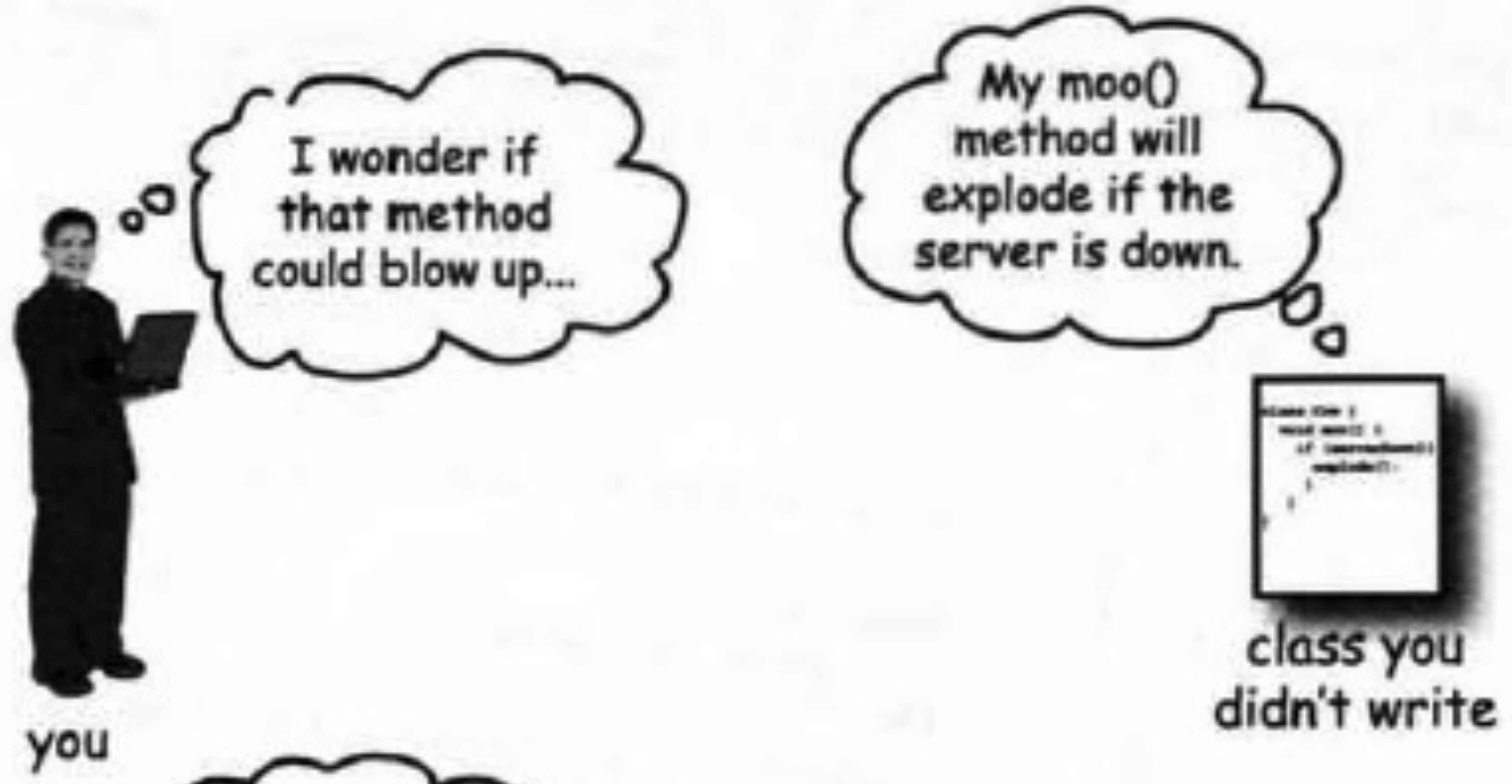


2. **That method does something risky, something that might not work at runtime.**



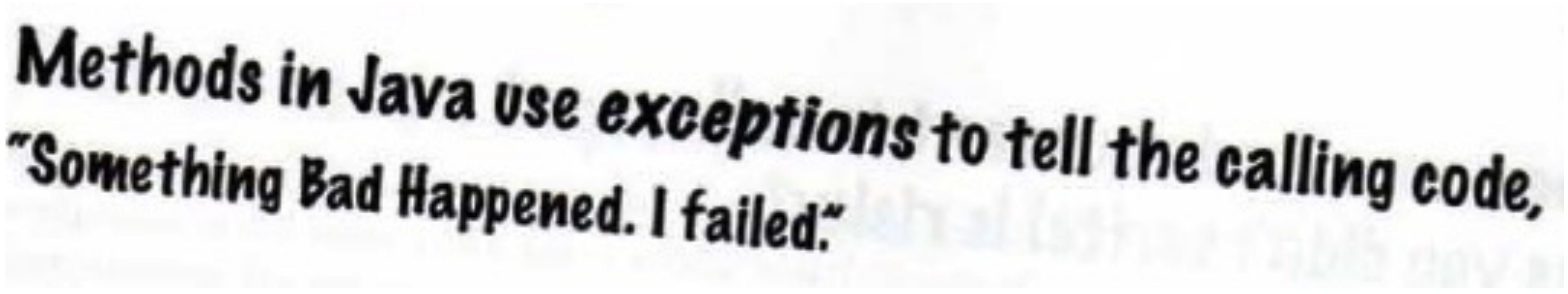
```
void moo() {
   if (serverDown) {
     explode();
   }
}
```

③ **You need to *know* that the method you're calling is risky.**

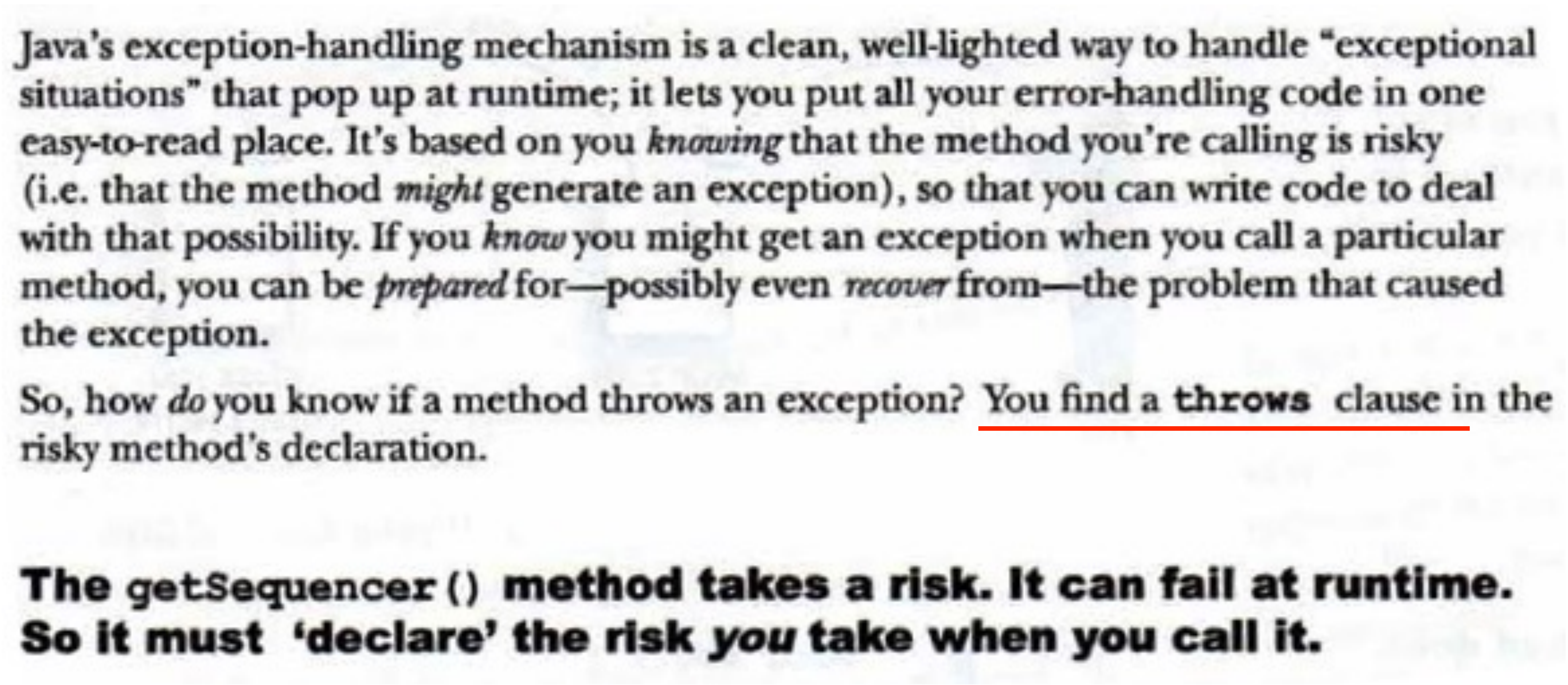

I wonder if that method could blow up...
My moo() method will explode if the server is down.
you
class you didn't write

④ **You then write code that can handle the failure if it *does* happen. You need to be prepared, just in case.**

Now that I know, I can take precautions.
write safely
you
your code



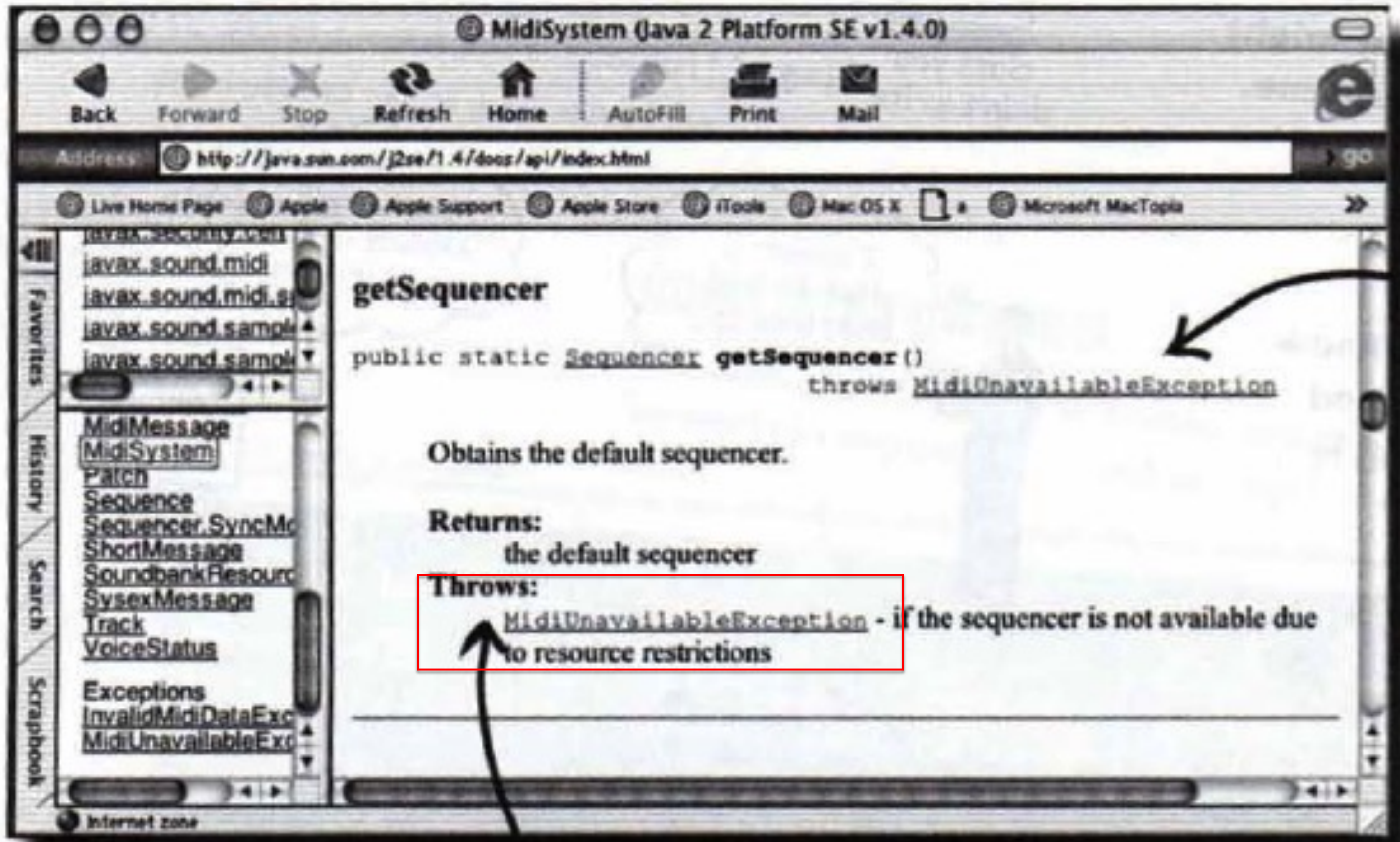
Methods in Java use *exceptions* to tell the calling code, "Something Bad Happened. I failed."



Java's exception-handling mechanism is a clean, well-lighted way to handle "exceptional situations" that pop up at runtime; it lets you put all your error-handling code in one easy-to-read place. It's based on you *knowing* that the method you're calling is risky (i.e. that the method *might* generate an exception), so that you can write code to deal with that possibility. If you *know* you might get an exception when you call a particular method, you can be *prepared* for—possibly even *recover* from—the problem that caused the exception.

So, how *do* you know if a method throws an exception? You find a `throws` clause in the risky method's declaration.

The `getSequencer()` method takes a risk. It can fail at runtime. So it must 'declare' the risk *you* take when you call it.



getSequencer

```
public static Sequencer getSequencer()
                        throws MidiUnavailableException
```

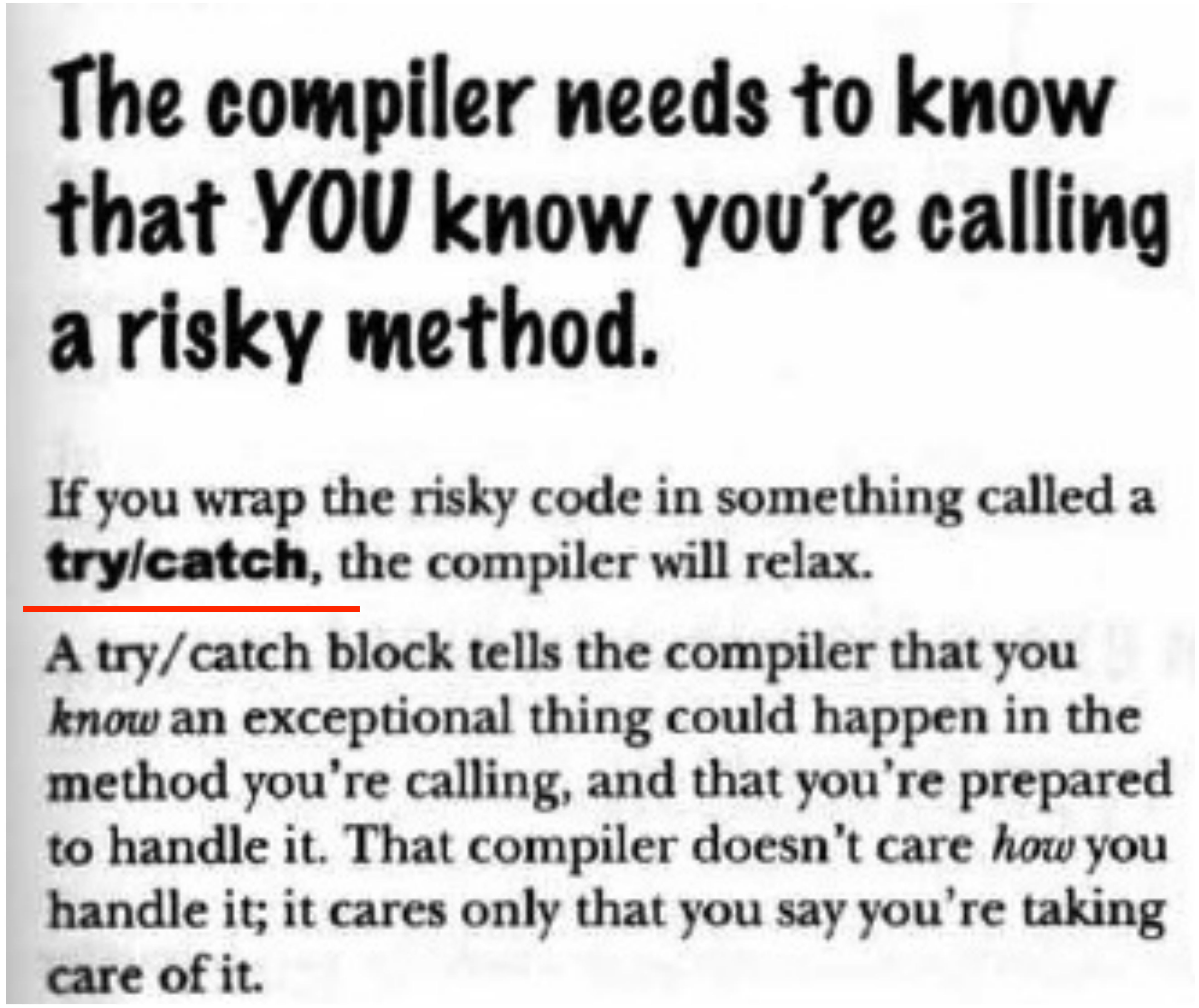
Obtains the default sequencer.

Returns:
the default sequencer

Throws:
MidiUnavailableException - if the sequencer is not available due to resource restrictions

The API does tell you that getSequencer() can throw an exception: MidiUnavailableException. A method has to declare the exceptions it might throw.

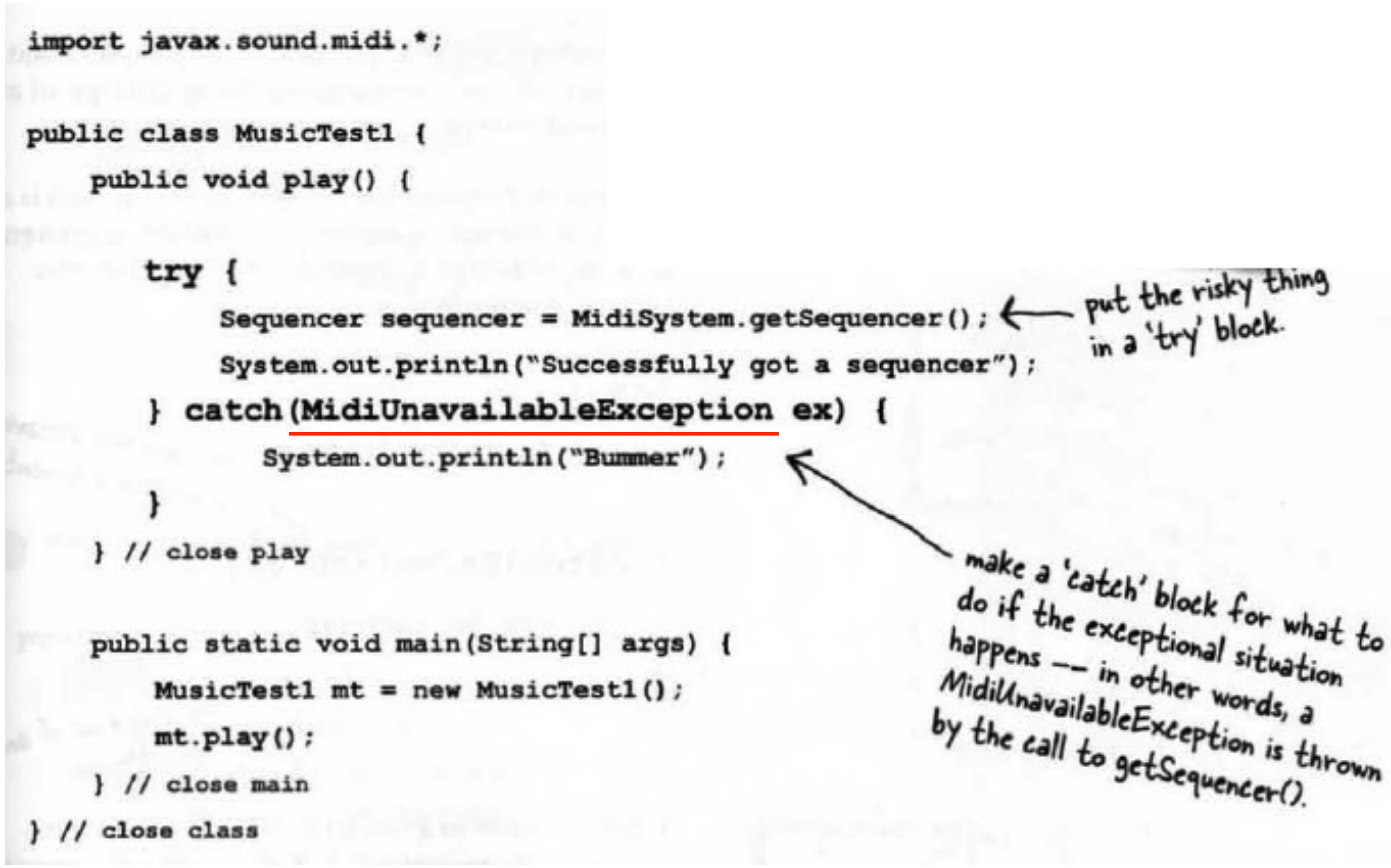
This part tells you WHEN you might get that exception -- in this case, because of resource restrictions (which could just means the sequencer is already being used).



The compiler needs to know that *YOU* know you're calling a risky method.

If you wrap the risky code in something called a **try/catch**, the compiler will relax.

A try/catch block tells the compiler that you *know* an exceptional thing could happen in the method you're calling, and that you're prepared to handle it. That compiler doesn't care *how* you handle it; it cares only that you say you're taking care of it.

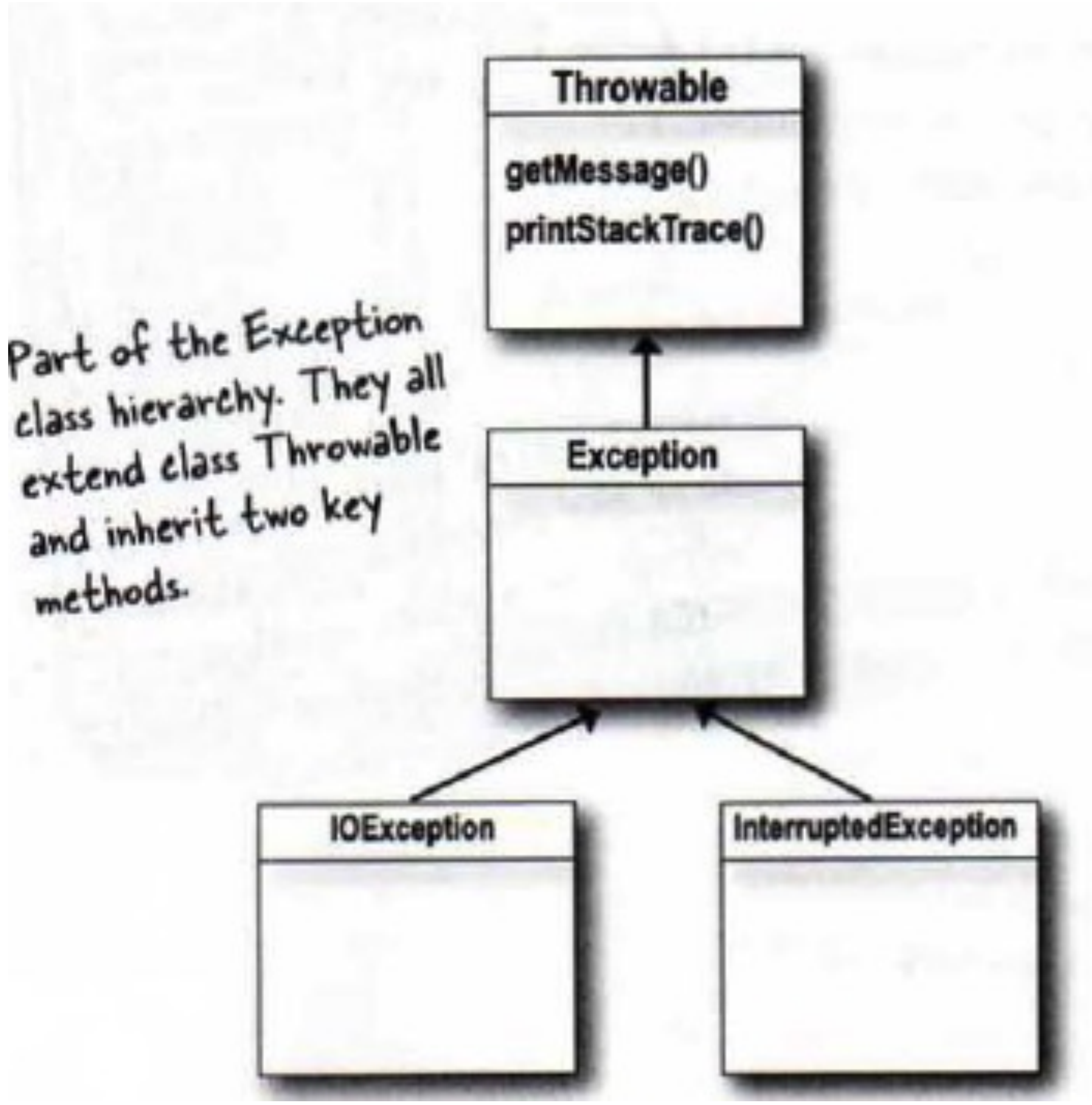


```java
import javax.sound.midi.*;

public class MusicTest1 {
    public void play() {

        try {
            Sequencer sequencer = MidiSystem.getSequencer();
            System.out.println("Successfully got a sequencer");
        } catch(MidiUnavailableException ex) {
               System.out.println("Bummer");
        }
    } // close play

    public static void main(String[] args) {
        MusicTest1 mt = new MusicTest1();
        mt.play();
    } // close main
} // close class
```

put the risky thing in a 'try' block.

make a 'catch' block for what to do if the exceptional situation happens -- in other words, a MidiUnavailableException is thrown by the call to getSequencer().

An exception is an object... of type Exception.

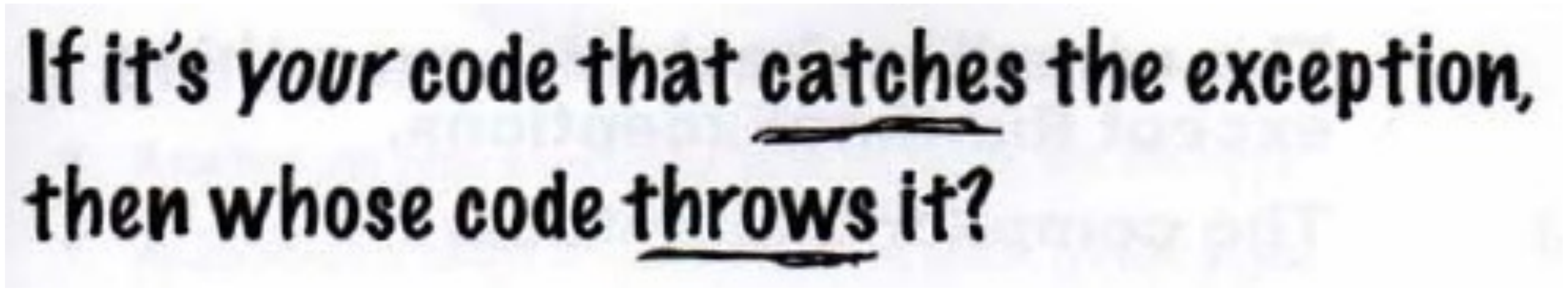

Part of the Exception class hierarchy. They all extend class Throwable and inherit two key methods.
Throwable
getMessage()
printStackTrace()
Exception
IOException
InterruptedException

```
try {
    // do risky thing

} catch(Exception ex) {
    // try to recover
}
```

it's just like declaring a method argument

This code only runs if an Exception is thrown.

What you write in a catch block depends on the exception that was thrown. For example, if a server is down you might use the catch block to try another server. If the file isn't there, you might ask the user for help finding it.



If it's *your* code that catches the exception,
then whose code throws it?

- 处理异常要比创建和抛出异常花费更多的时间。
- 当代码调用有风险的方法(声明异常的方法)时，则该代码处理异常。

① Risky, exception-throwing code:

this method MUST tell the world (by declaring) that it throws a BadException

```
public void takeRisk() throws BadException {
   if (abandonAllHope) {
     throw new BadException();
   }
}
```

create a new Exception object and throw it.

② Your code that *calls* the risky method:

```
public void crossFingers() {
   try {
      anObject.takeRisk();
   } catch (BadException ex) {
      System.out.println("Aaargh!");
      ex.printStackTrace();
   }
}
```

If you can't recover from the exception, at LEAST get a stack trace using the printStackTrace() method that all exceptions inherit.

One method will catch what another method throws. An exception is always thrown back to the caller.

The method that throws has to declare that it might throw the exception.

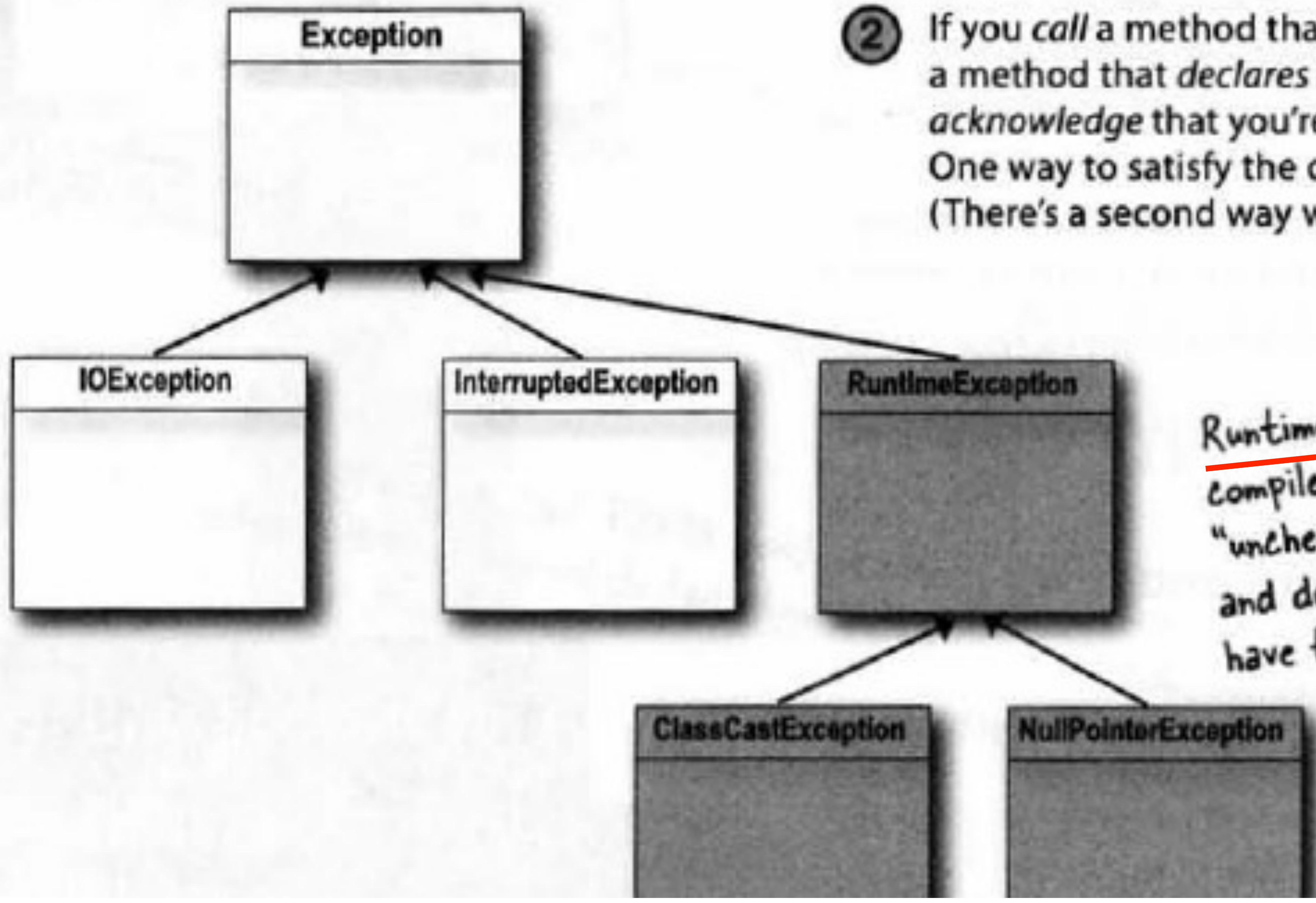
The compiler checks for everything except RuntimeExceptions.

Exceptions that are NOT subclasses of RuntimeException are checked for by the compiler. They're called "checked exceptions"

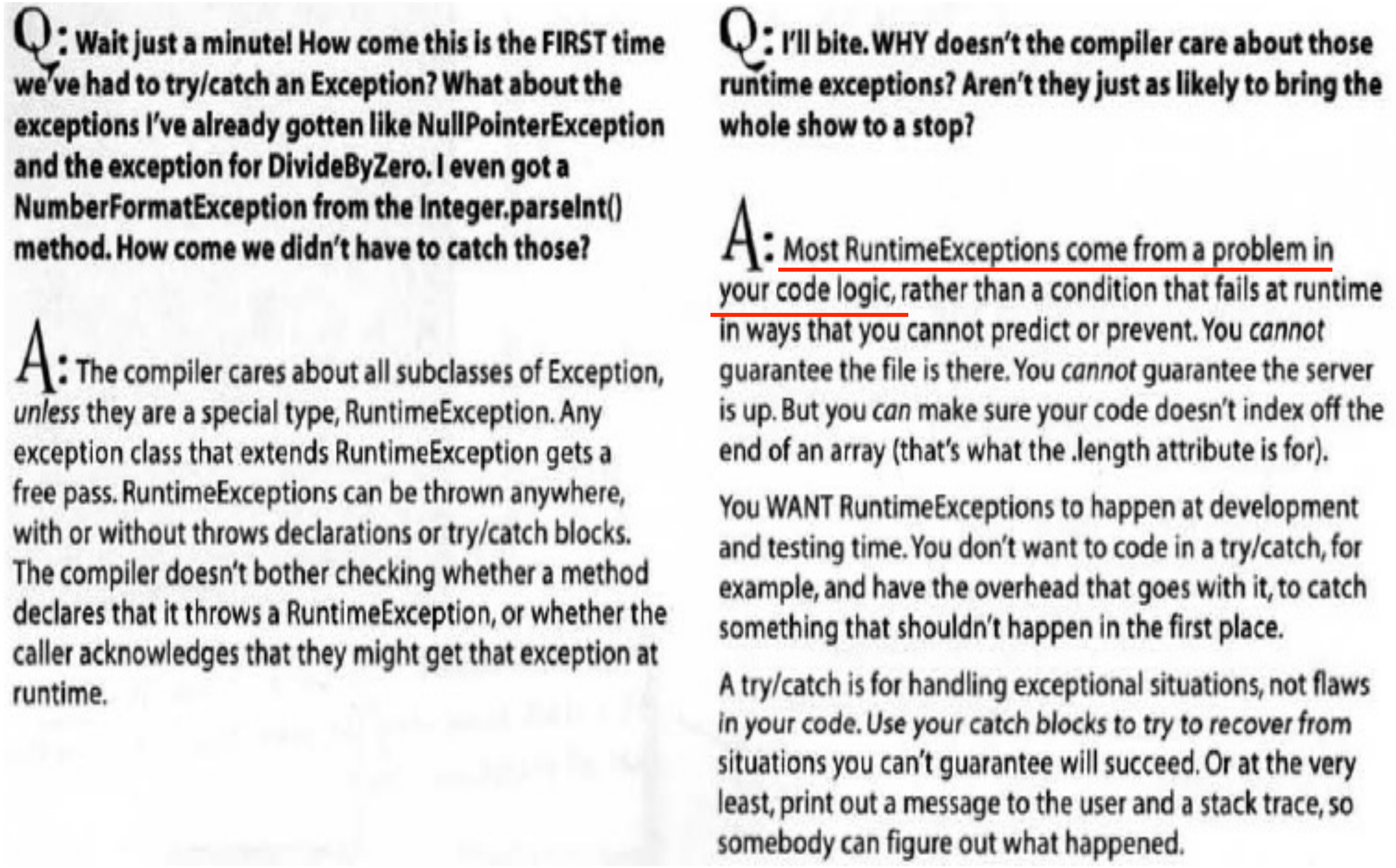
The compiler guarantees:

1. If you *throw* an exception in your code you *must* declare it using the *throws* keyword in your method declaration.

2. If you *call* a method that throws an exception (in other words, a method that *declares* it throws an exception), you must *acknowledge* that you're aware of the exception possibility. One way to satisfy the compiler is to wrap the call in a try/catch. (There's a second way we'll look at a little later in this chapter.)



RuntimeExceptions are NOT checked by the compiler. They're known as (big surprise here) "unchecked exceptions". You can throw, catch, and declare RuntimeExceptions, but you don't have to, and the compiler won't check.



Q: Wait just a minute! How come this is the FIRST time we've had to try/catch an Exception? What about the exceptions I've already gotten like NullPointerException and the exception for DivideByZero. I even got a NumberFormatException from the Integer.parseInt() method. How come we didn't have to catch those?

A: The compiler cares about all subclasses of Exception, *unless* they are a special type, RuntimeException. Any exception class that extends RuntimeException gets a free pass. RuntimeExceptions can be thrown anywhere, with or without throws declarations or try/catch blocks. The compiler doesn't bother checking whether a method declares that it throws a RuntimeException, or whether the caller acknowledges that they might get that exception at runtime.

Q: I'll bite. WHY doesn't the compiler care about those runtime exceptions? Aren't they just as likely to bring the whole show to a stop?

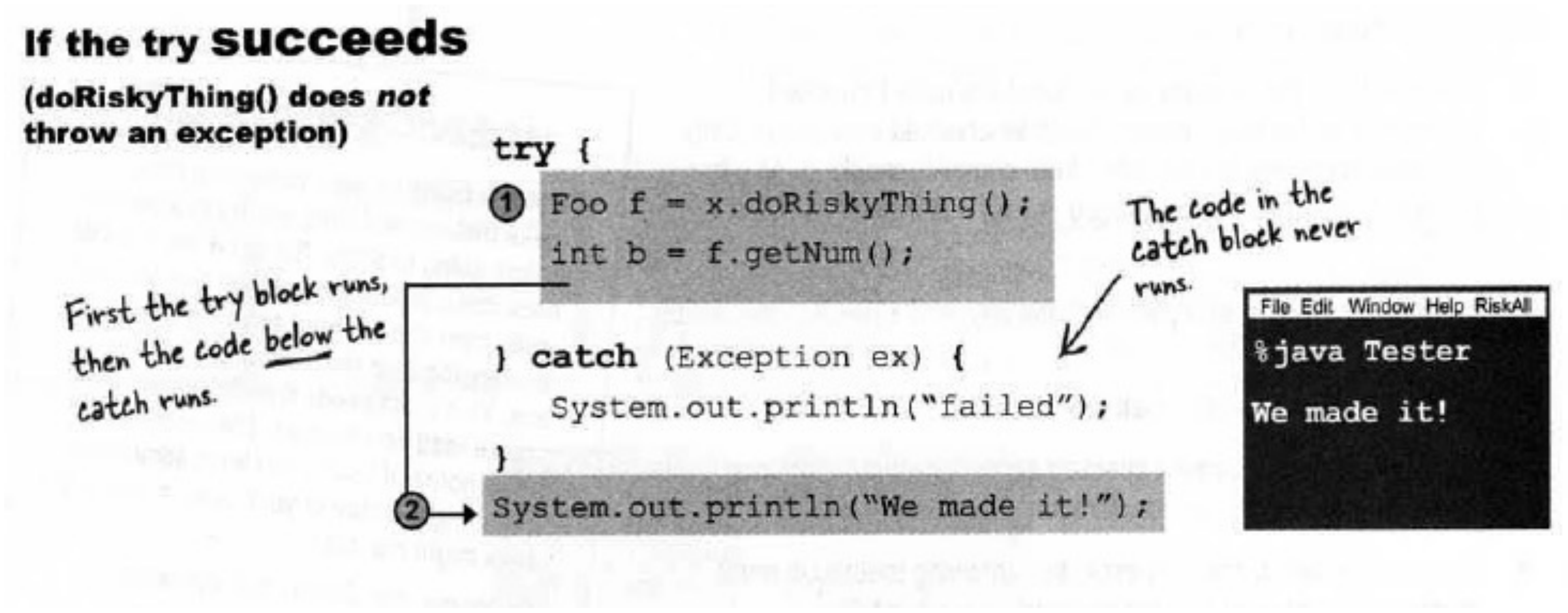
A: Most RuntimeExceptions come from a problem in your code logic, rather than a condition that fails at runtime in ways that you cannot predict or prevent. You *cannot* guarantee the file is there. You *cannot* guarantee the server is up. But you *can* make sure your code doesn't index off the end of an array (that's what the .length attribute is for).

You WANT RuntimeExceptions to happen at development and testing time. You don't want to code in a try/catch, for example, and have the overhead that goes with it, to catch something that shouldn't happen in the first place.

A try/catch is for handling exceptional situations, not flaws in your code. *Use your catch blocks to try to recover from* situations you can't guarantee will succeed. Or at the very least, print out a message to the user and a stack trace, so somebody can figure out what happened.

- 如存在风险，抛出异常。
- 异常是一个exception类型的对象。
- 编译器会忽视RuntimeException类型的异常。RuntimeException类型的异常不需被声明或者在try/catch中处理。
- 编译器只关心可检查异常，其必须在代码中声明和处理。
- 方法体中用throw关键词抛出异常对象 throw new Exception ();
- 抛出可检查异常的方法必须声明异常 throws Exception。
- 编译器会检查可检查异常是否被处理，即 try-catch
- 可以一直 throws

Flow control in try/catch blocks



If the try succeeds

(doRiskyThing() does *not* throw an exception)

```
try {
  ① Foo f = x.doRiskyThing();
    int b = f.getNum();

} catch (Exception ex) {
    System.out.println("failed");
}
② System.out.println("We made it!");
```

First the try block runs, then the code below the catch runs.
The code in the catch block never runs.
File Edit Window Help RiskAll

```
%java Tester
We made it!
```

If the try **fails**

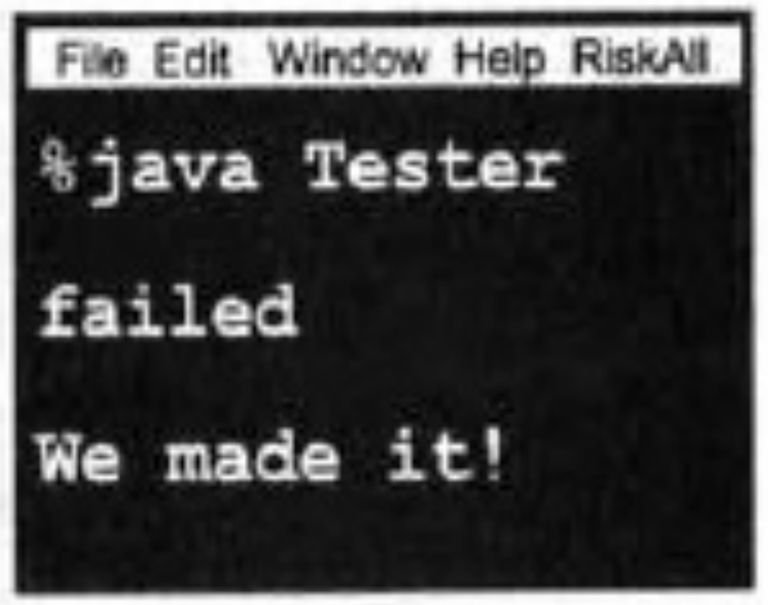
(because doRiskyThing() *does* throw an exception)

```
try {
  ① Foo f = x.doRiskyThing();
    int b = f.getNum();

} catch (Exception ex) {
  ② System.out.println("failed");
}
③ System.out.println("We made it!");
```

The try block runs, but the call to doRiskyThing() throws an exception, so the rest of the try block doesn't run.

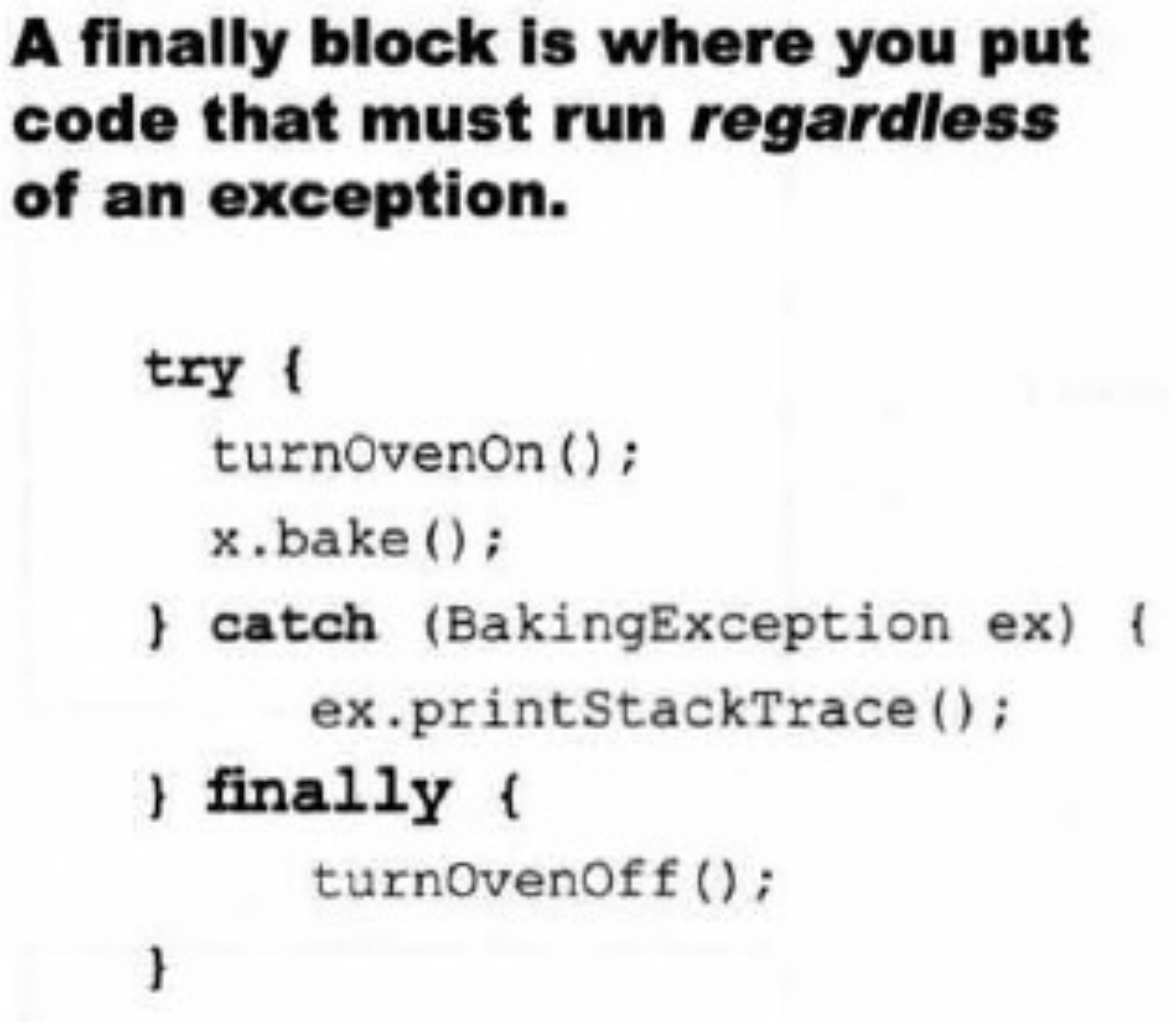
The catch block runs, then the method continues on.

The rest of the try block never runs, which is a Good Thing because the rest of the try depends on the success of the call to doRiskyThing().



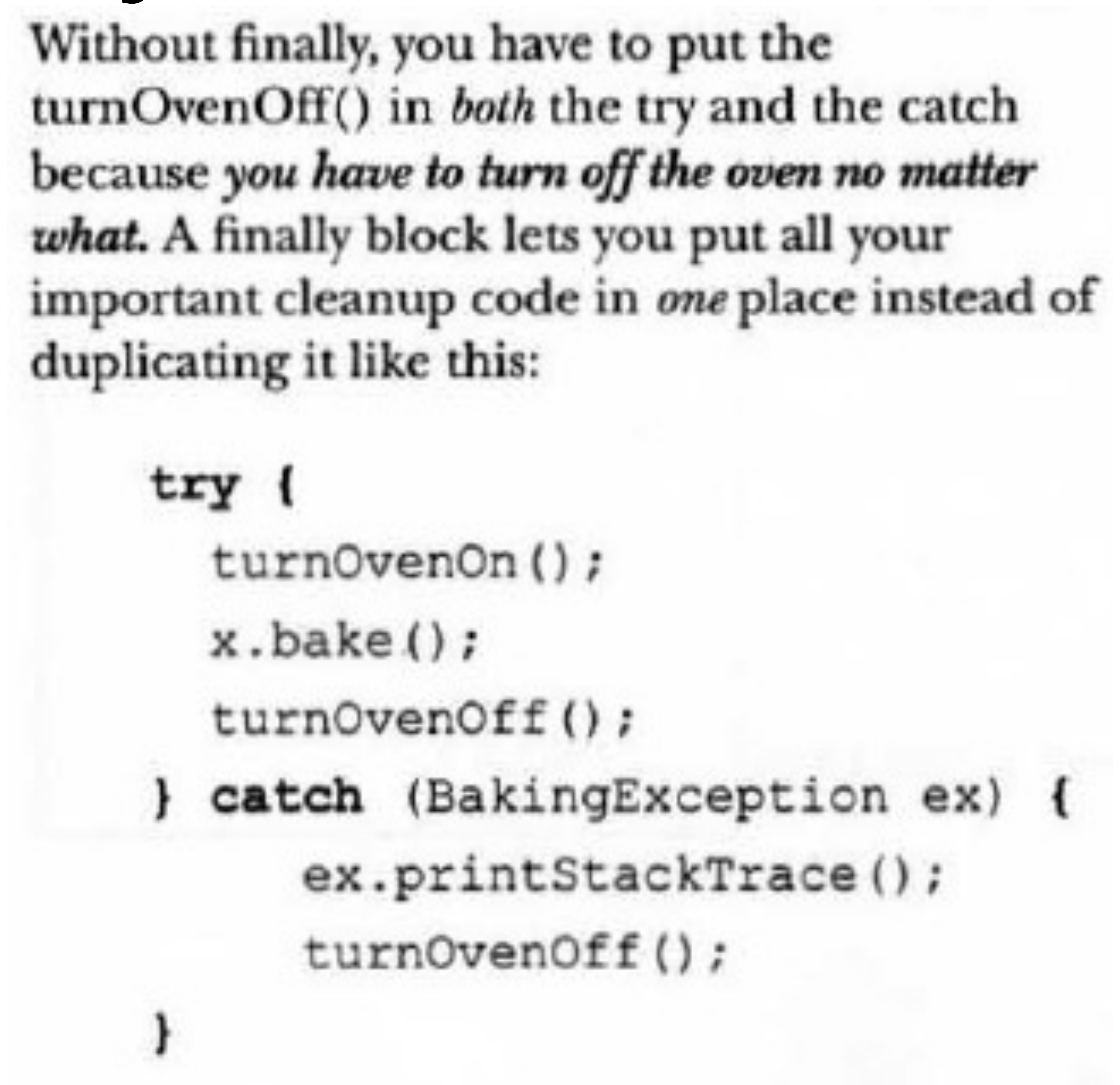
```
%java Tester

failed

We made it!
```

Finally



A finally block is where you put code that must run *regardless* of an exception.

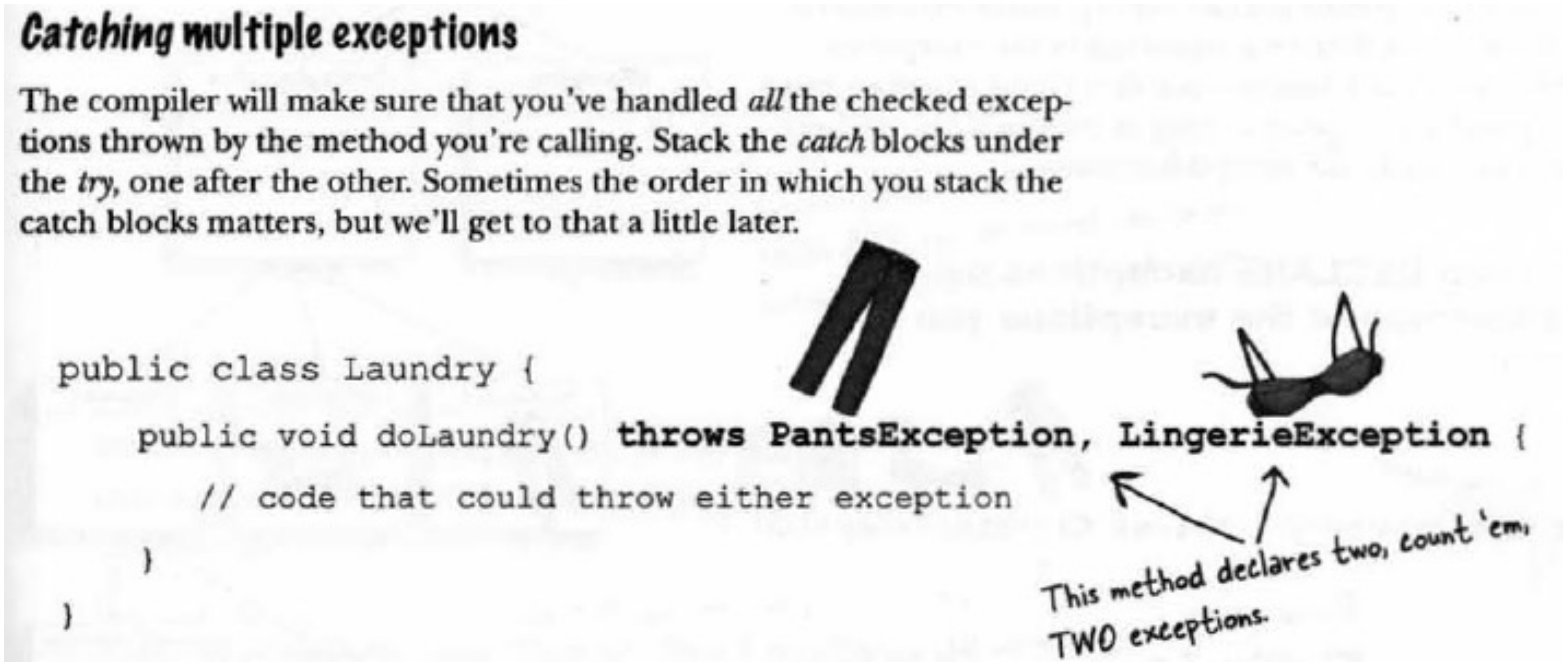
```
try {
  turnOvenOn();
  x.bake();
} catch (BakingException ex) {
    ex.printStackTrace();
} finally {
    turnOvenOff();
}
```



Without finally, you have to put the turnOvenOff() in *both* the try and the catch because ***you have to turn off the oven no matter what.*** A finally block lets you put all your important cleanup code in *one* place instead of duplicating it like this:

```
try {
  turnOvenOn();
  x.bake();
  turnOvenOff();
} catch (BakingException ex) {
    ex.printStackTrace();
    turnOvenOff();
}
```

Multiple exceptions



Catching multiple exceptions

The compiler will make sure that you've handled *all* the checked exceptions thrown by the method you're calling. Stack the *catch* blocks under the *try*, one after the other. Sometimes the order in which you stack the catch blocks matters, but we'll get to that a little later.

```
public class Laundry {

    public void doLaundry() throws PantsException, LingerieException {

       // code that could throw either exception

    }

}
```

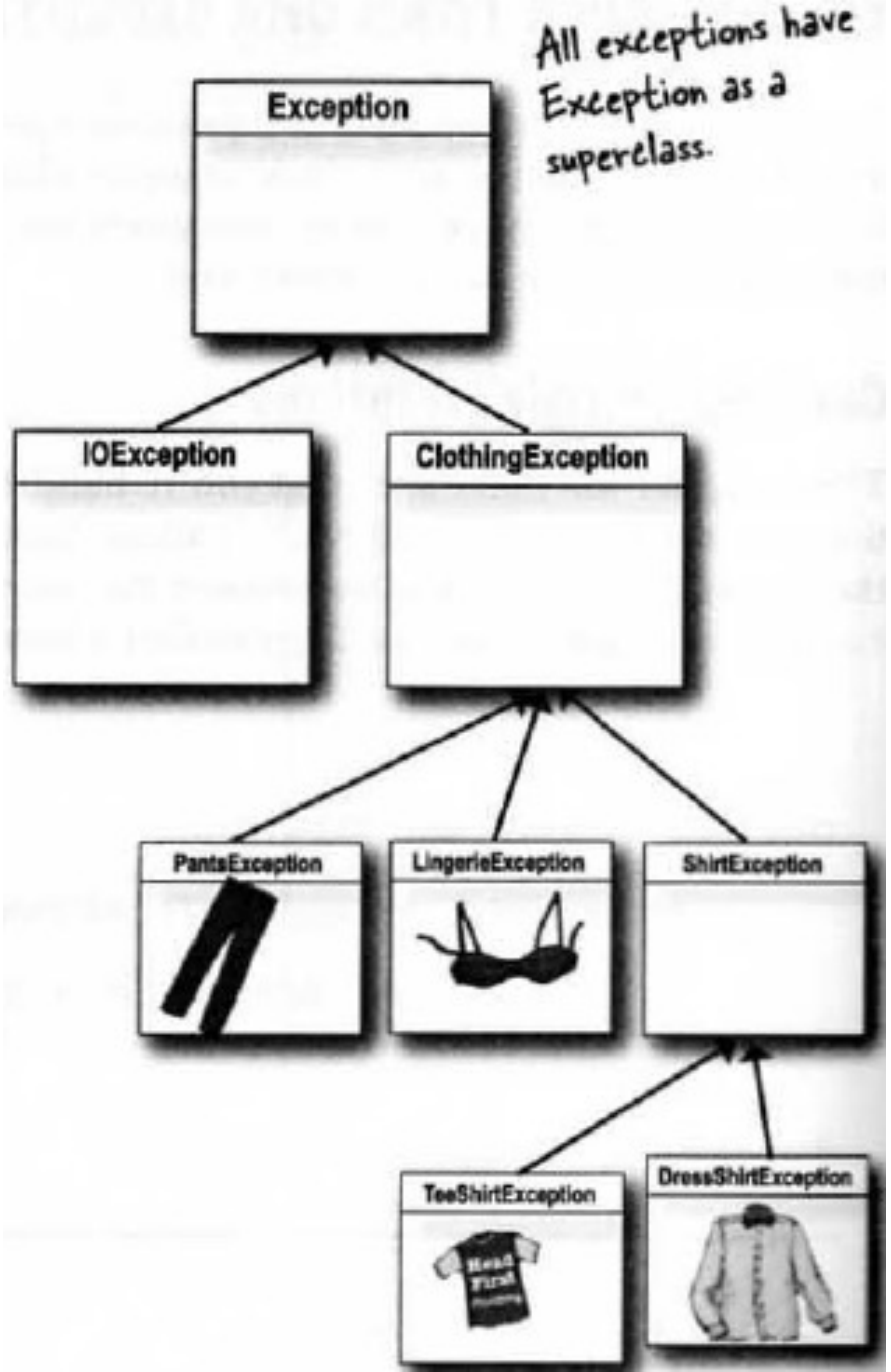
This method declares two, count 'em, TWO exceptions.

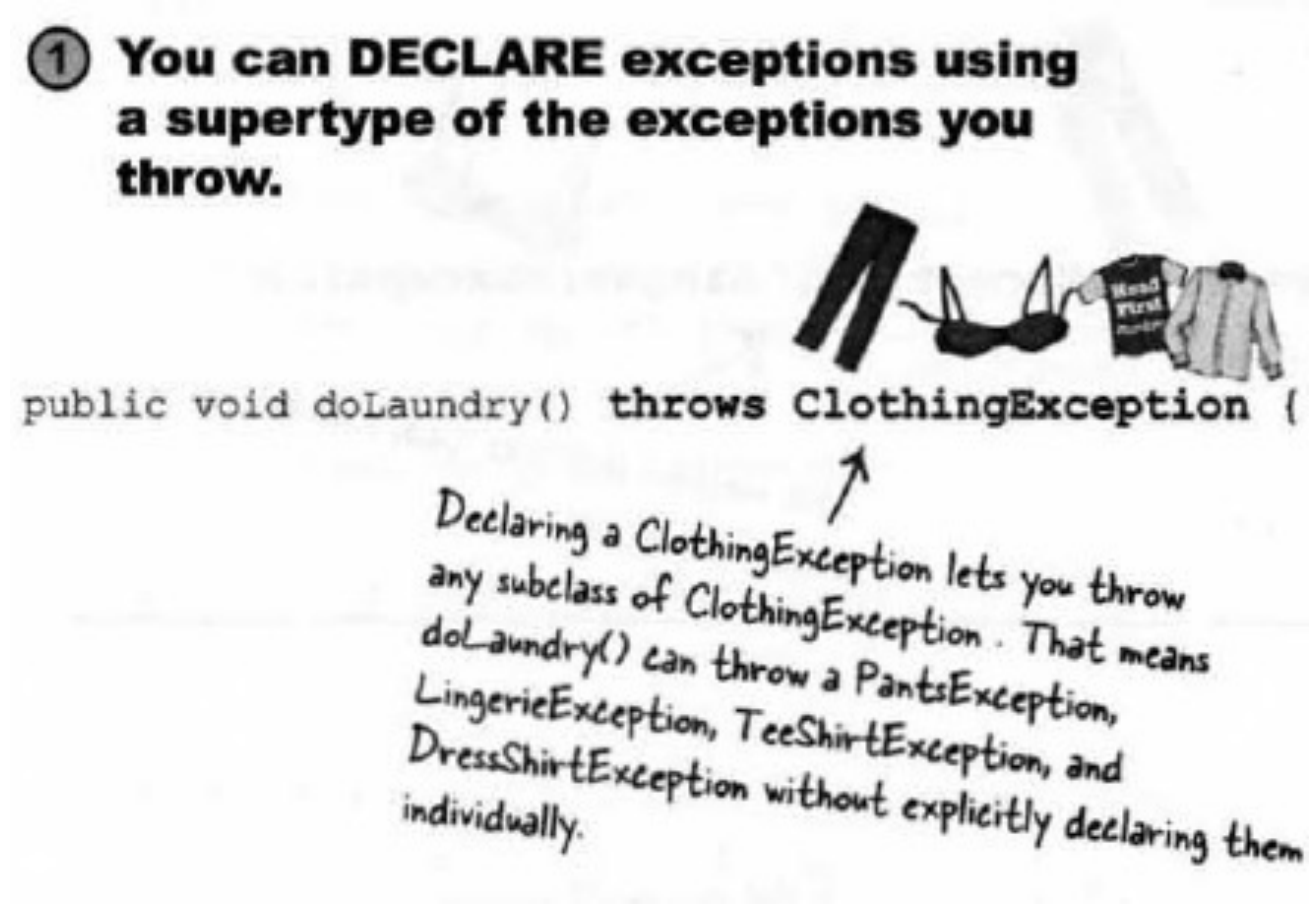
```
public class Foo {

    public void go() {

        Laundry laundry = new Laundry();

        try {

            laundry.doLaundry();

        } catch(PantsException pex) {

            // recovery code


        } catch(LingerieException lex) {

            // recovery code

        }

    }

}
```

if doLaundry() throws a PantsException, it lands in the PantsException catch block.

if doLaundry() throws a LingerieException, it lands in the LingerieException catch block.

Exceptions are polymorphic





1. **You can DECLARE exceptions using a supertype of the exceptions you throw.**

```
public void doLaundry() throws ClothingException {
```

Declaring a ClothingException lets you throw any subclass of ClothingException. That means doLaundry() can throw a PantsException, LingerieException, TeeShirtException, and DressShirtException without explicitly declaring them individually.

② You can CATCH exceptions using a supertype of the exception thrown.

```
try {

   laundry.doLaundry();
```

can catch any ClothingException subclass

```
} catch(ClothingException cex) {

     // recovery code

}
```

```
try {

   laundry.doLaundry();
```

can catch only TeeShirtException and DressShirtException

```
} catch(ShirtException sex) {

     // recovery code

}
```

Just because you CAN catch everything with one big super polymorphic catch, doesn't always mean you SHOULD.

You *could* write your exception-handling code so that you specify only *one* catch block, using the supertype Exception in the catch clause, so that you'll be able to catch *any* exception that might be thrown.

```
try {

   laundry.doLaundry();

} catch(Exception ex) {

     // recovery code...

}
```

Recovery from WHAT? This catch block will catch ANY and all exceptions, so you won't automatically know what went wrong.

Write a different catch block for each exception that you need to handle uniquely.

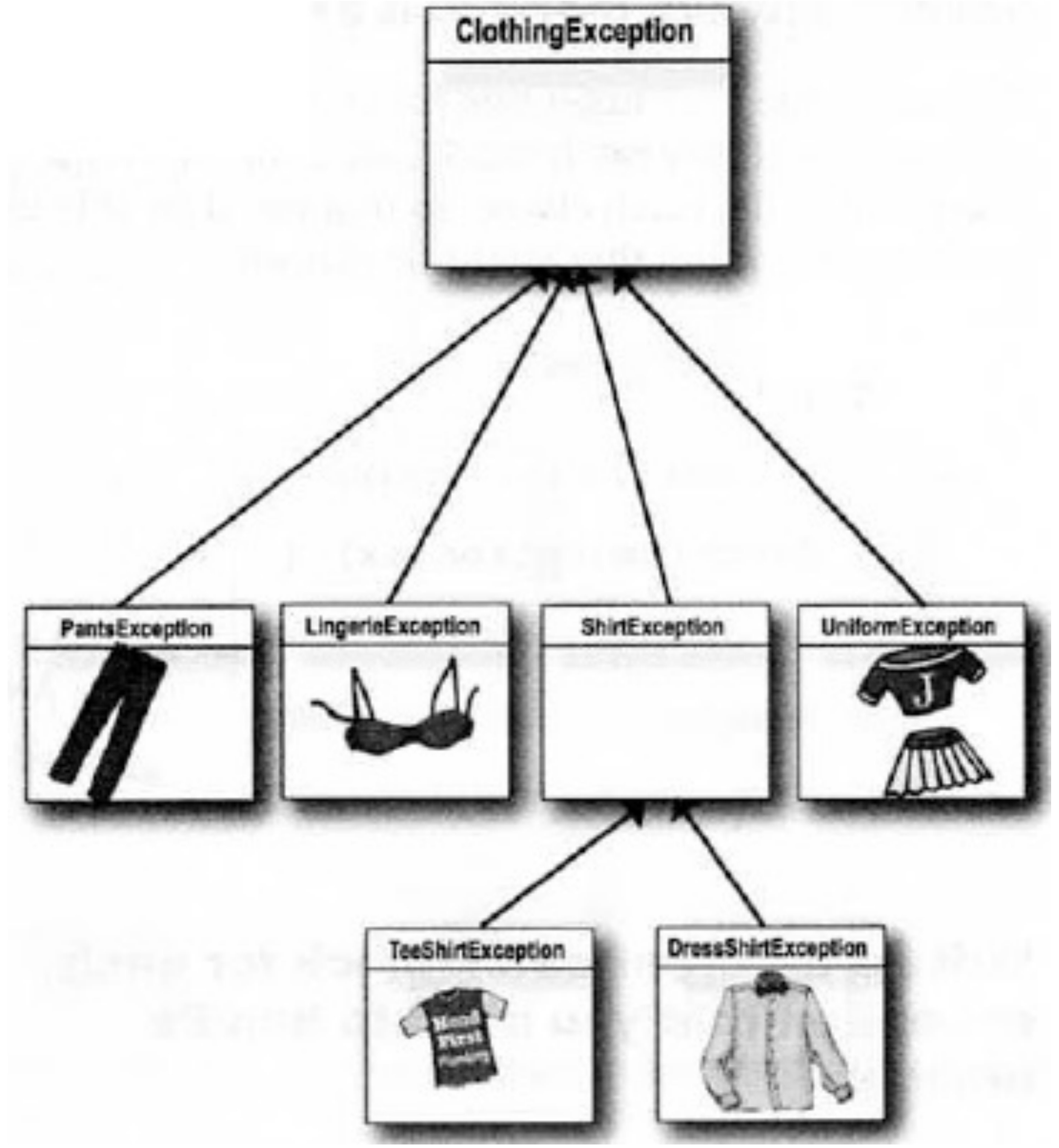
For example, if your code deals with (or recovers from) a TeeShirtException differently than it handles a LingerieException, write a catch block for each. But if you treat all other types of ClothingException in the same way, then add a ClothingException *catch to handle the rest.*

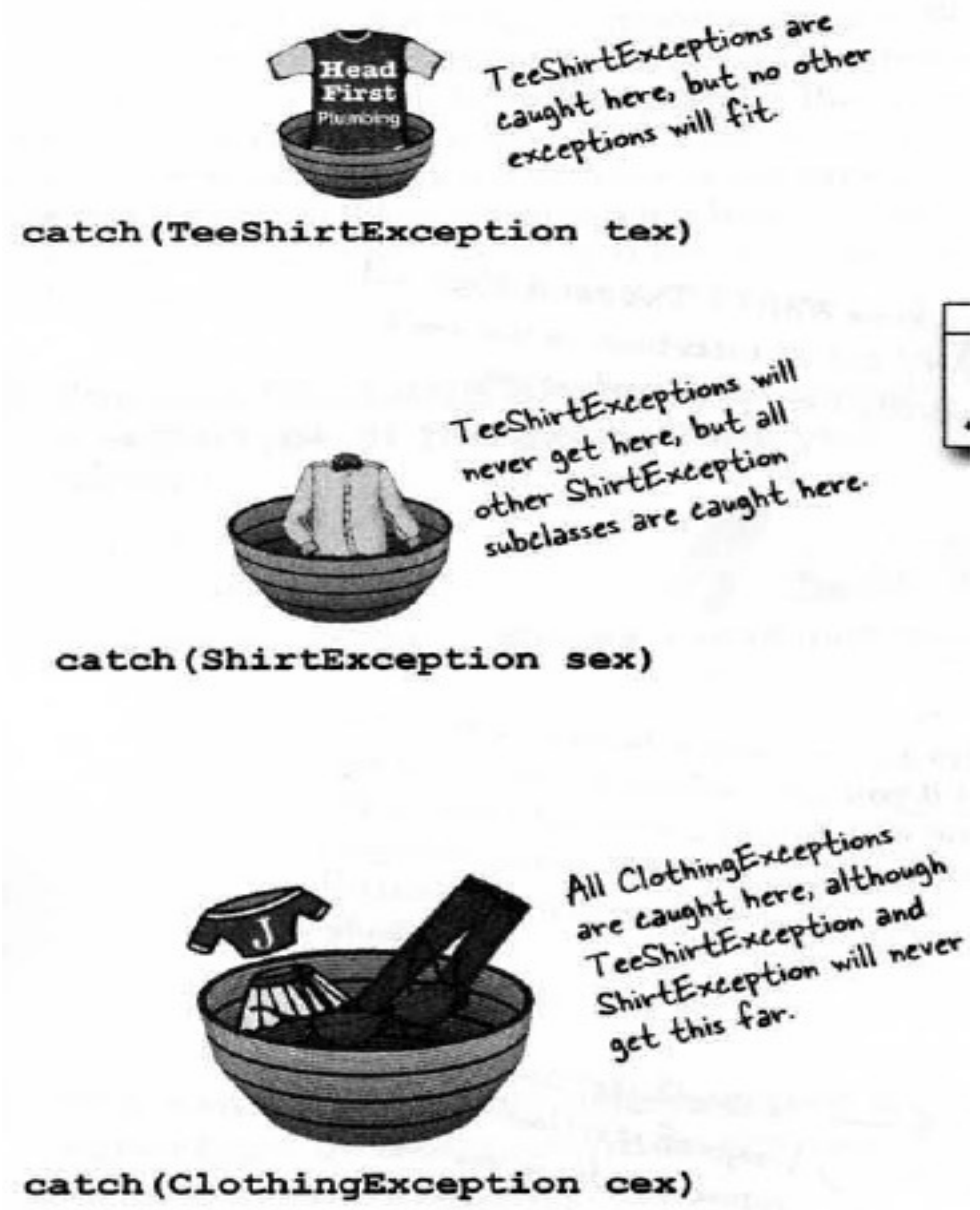
```
try {

   laundry.doLaundry();

} catch(TeeShirtException tex) {

    // recovery from TeeShirtException

} catch(LingerieException lex) {

    // recovery from LingerieException

} catch(ClothingException cex) {

    // recovery from all others

}
```

TeeShirtExceptions and LingerieExceptions need different recovery code, so you should use different catch blocks.

All other ClothingExceptions are caught here.

Multiple catch blocks must be ordered from smallest to biggest




TeeShirtExceptions are caught here, but no other exceptions will fit.
catch(TeeShirtException tex)
TeeShirtExceptions will never get here, but all other ShirtException subclasses are caught here.
catch(ShirtException sex)
All ClothingExceptions are caught here, although TeeShirtException and ShirtException will never get this far.
catch(ClothingException cex)

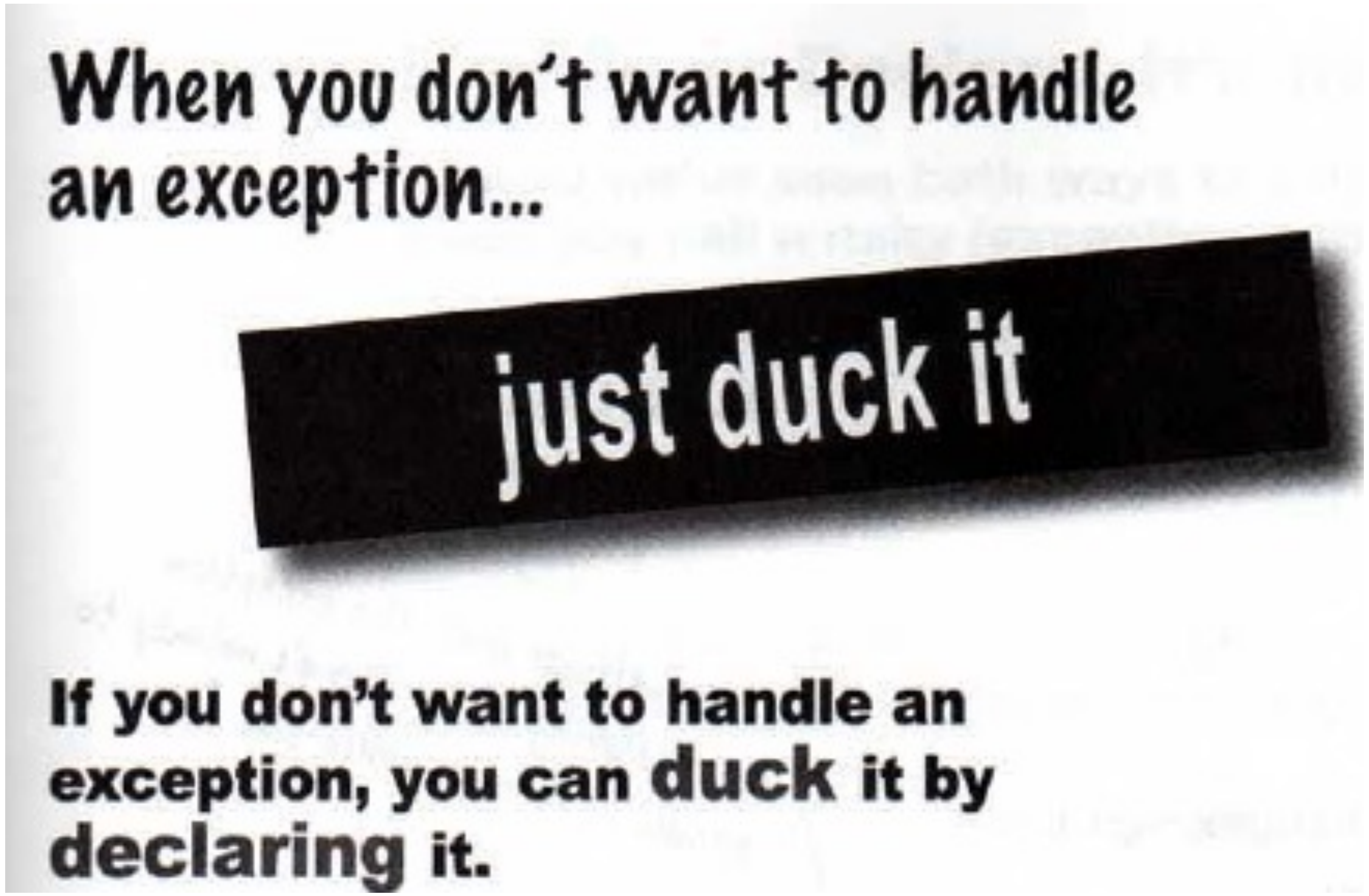
- 异常类位于继承树位置越高，能捕获的“篮子”就越大。
- Exception能够捕获所有的异常，包括运行时异常。

You can't put bigger baskets above smaller baskets.

Well, you *can* but it won't compile. Catch blocks are not like overloaded methods where the best match is picked. With catch blocks, the JVM simply starts at the first one and works its way down until it finds a catch that's broad enough (in other words, high enough on the inheritance tree) to handle the exception. If your first catch block is **`catch(Exception ex)`**, the compiler knows there's no point in adding any others—they'll never be reached.

Siblings can be in any order, because they can't catch one another's exceptions.

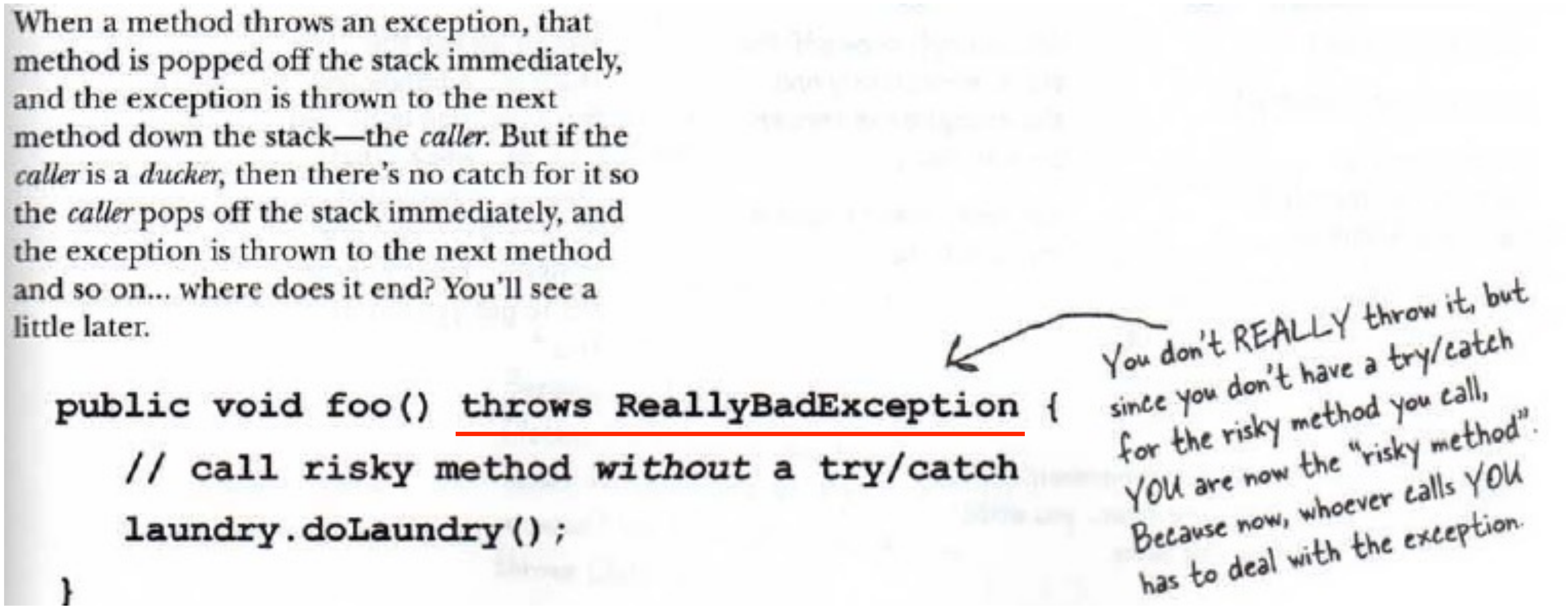
You could put ShirtException above LingerieException and nobody would mind. Because even though ShirtException is a bigger (broader) type because it can catch other classes (its own subclasses), ShirtException can't catch a LingerieException so there's no problem.



When you don't want to handle an exception...

just duck it

If you don't want to handle an exception, you can duck it by declaring it.



When a method throws an exception, that method is popped off the stack immediately, and the exception is thrown to the next method down the stack—the *caller*. But if the *caller* is a *ducker*, then there's no catch for it so the *caller* pops off the stack immediately, and the exception is thrown to the next method and so on... where does it end? You'll see a little later.

```
public void foo() throws ReallyBadException {
   // call risky method without a try/catch
   laundry.doLaundry();
}
```

You don't REALLY throw it, but since you don't have a try/catch for the risky method you call, YOU are now the "risky method". Because now, whoever calls YOU has to deal with the exception.

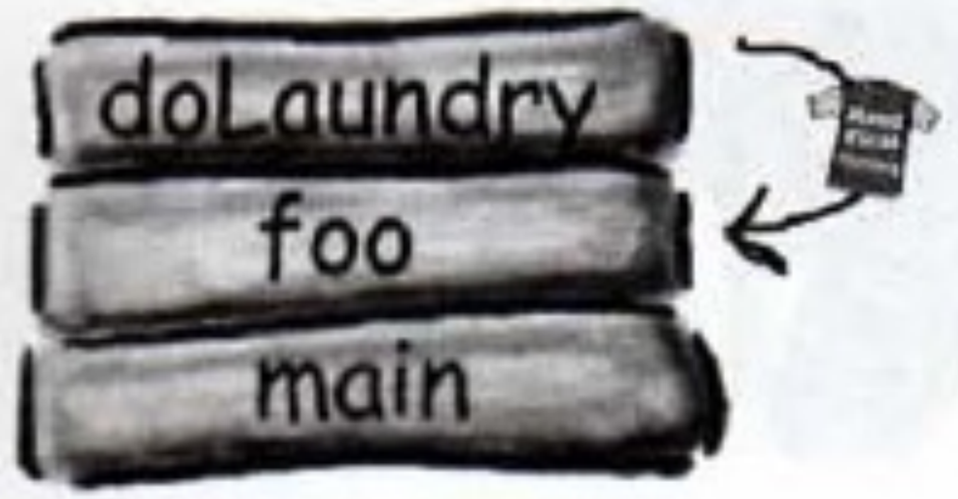
Ducking (by declaring) only delays the inevitable

Sooner or later, *somebody* has to deal with it. But what if *main()* ducks the exception?

```
public class Washer {
    Laundry laundry = new Laundry();

    public void foo() throws ClothingException {
       laundry.doLaundry();
    }

   public static void main (String[] args) throws ClothingException {
       Washer a = new Washer();
       a.foo();
   }
}
```

Both methods duck the exception (by declaring it) so there's nobody to handle it! This compiles just fine.

1 doLaundry() throws a ClothingException

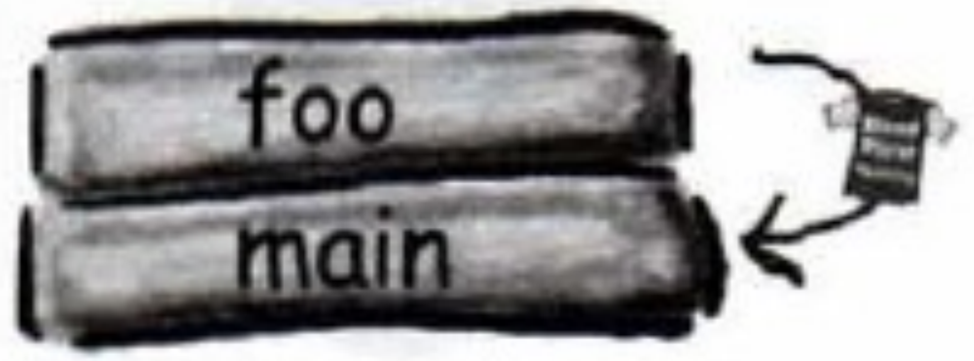


main() calls foo()

foo() calls doLaundry()

doLaundry() is running and throws a ClothingException

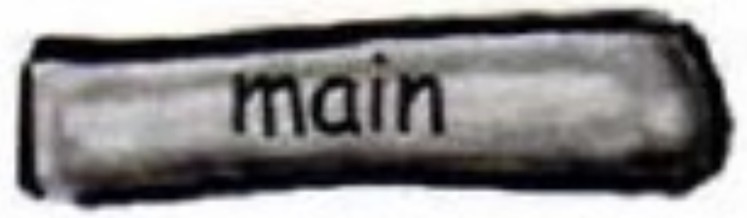
2 foo() ducks the exception



doLaundry() pops off the stack immediately and the exception is thrown back to foo().

But foo() doesn't have a try/catch, so...

3 main() ducks the exception



foo() pops off the stack immediately and the exception is thrown back to... who? What? There's nobody left but the JVM, and it's thinking, "Don't expect ME to get you out of this."

4 The JVM shuts down

Handle or Declare. It's the law.

So now we've seen both ways to satisfy the compiler when you call a risky (exception-throwing) method.

1 HANDLE

Wrap the risky call in a try/catch

```
try {
    laundry.doLaundry();
} catch(ClothingException cex) {
       // recovery code
}
```

This had better be a big enough catch to handle all exceptions that doLaundry() might throw. Or else the compiler will still complain that you're not catching all of the exceptions.

② DECLARE (duck it)

Declare that YOUR method throws the same exceptions as the risky method you're calling.

```
void foo() throws ClothingException {
   laundry.doLaundry();
}
```

The doLaundry() method throws a ClothingException, but by declaring the exception, the foo() method gets to duck the exception. No try/catch.

But now this means that whoever calls the foo() method has to follow the Handle or Declare law. If foo() ducks the exception (by declaring it), and main() calls foo(), then main() has to deal with the exception.

```
public class Washer {
    Laundry laundry = new Laundry();

    public void foo() throws ClothingException {
       laundry.doLaundry();
    }

   public static void main (String[] args) {
       Washer a = new Washer();
       a.foo();
   }
}
```

TROUBLE!!

Now main() won't compile, and we get an "unreported exception" error. As far as the compiler's concerned, the foo() method throws an exception.

Because the foo() method ducks the ClothingException thrown by doLaundry(), main() has to wrap a.foo() in a try/catch, or main() has to declare that it, too, throws ClothingException!

Getting back to our music code...

Now that you've completely forgotten, we started this chapter with a first look at some JavaSound code. We created a Sequencer object but it wouldn't compile because the method Midi.getSequencer() declares a checked exception (MidiUnavailableException). But we can fix that now by wrapping the call in a try/catch.

```
public void play() {
        try {

            Sequencer sequencer = MidiSystem.getSequencer();
            System.out.println("Successfully got a sequencer");

        } catch(MidiUnavailableException ex) {
            System.out.println("Bummer");
        }
    } // close play
```

No problem calling getSequencer(), now that we've wrapped it in a try/catch block.

The catch parameter has to be the 'right' exception. If we said 'catch(FileNot FoundException f), the code would not compile, because polymorphically a MidiUnavilableException won't fit into a FileNotFoundException. Remember it's not enough to have a catch block... you have to catch the thing being thrown!

Exception Rules

1 You cannot have a catch or finally without a try

```
void go() {
   Foo f = new Foo();
   f.foof();
   catch(FooException ex) { }
}
```

NOT LEGAL! Where's the try?

2 You cannot put code between the try and the catch

```
try {
   x.doStuff();
}
int y = 43;
} catch(Exception ex) { }
```

NOT LEGAL! You can't put code between the try and the catch.

3 A try MUST be followed by either a catch or a finally

```
try {
   x.doStuff();
} finally {
   // cleanup
}
```

LEGAL because you have a finally, even though there's no catch. But you cannot have a try by itself.

4 A try with only a finally (no catch) must still declare the exception.

```
void go() throws FooException {
    try {
       x.doStuff();
    } finally { }
}
```

A try without a catch doesn't satisfy the handle or declare law

在继承中重写方法时抛出异常的问题

规则1：异常范围一致性原则

子类重写父类方法时：

　允许抛出与父类方法完全相同的受检异常（checked exception）；

　允许抛出父类方法声明异常的子类异常（更具体的异常）；

　允许不抛出任何受检异常（缩减异常范围）；

　禁止抛出比父类方法声明更宽泛或无关的受检异常。

　非检查型异常（unchecked exceptions）（如 RuntimeException 及其子类）不受此规则限制，子类可自由抛出。

规则2: 多继承场景下的异常交集原则

若子类同时满足以下条件：

- 重写父类中声明异常的方法；
- 实现某接口中同名且声明异常的方法；

则子类重写方法的异常声明必须满足：

- 抛出父类声明异常与接口声明异常的交集；
- 或不抛出任何检查型异常。

```
class Database {
    void connect() throws IOException { ... }
}

class MySQL extends Database {
    @Override
    void connect() throws IOException, SQLException { ... } // 假设允许
}

// 通用工具类（仅处理 IOException）
class DatabaseUtils {
    static void safeConnect(Database db) {
        try {
            db.connect(); // 编译器认为只会抛出 IOException
        } catch (IOException e) {
            // 处理 IOException
        }
        // SQLException 会逃逸！
    }
}

// 使用场景
DatabaseUtils.safeConnect(new MySQL()); // 可能抛出未处理的 SQLException！
```

```
interface MyInterface {
    void save() throws SQLException;
}

class Parent {
    void save() throws IOException { ... }
}

// 子类需同时满足父类和接口的异常声明
class Child extends Parent implements MyInterface {
    @Override
    void save() { ... }  // 合法：不抛出异常（交集为空）
    // 或抛出 IOException 和 SQLException 的共同子类（若存在）
}
```

- 现有类
- class A{
- public void show() throws IOException,ClassNotFoundException, ArithmeticException {
-         System.out.println("show");
-     }
- }
- 以下类定义正确的是
- A. class Son extends A {
-    public void show() throws
- IOException,ClassNotFoundException, ArithmeticException，NullPointerException {
- System.out.println("show");
-     }
- }
- B. class Son extends A {
- public void show() throws
- IOException,ClassNotFoundException, ParseException {
-         System.out.println("show");
-     }
- }
- C. class Son extends A {
- public void show() throws
- IOException,ClassNotFoundException{
-         System.out.println("show");
-     }
- }
- D. class Son extends A {
- public void show() {
-         System.out.println("show");
-     }
- }
- [答案]ACD

- 例子1
- public class TestRegularExperssion {
- public void printA(float a,float b)throws SQLException
- {
- }
- }
- class TestRegularExpressionA extends TestRegularExperssion
- {
- public void printA(float a,float b)throws NullPointerException
- {
- }
- } //编译通过

- 例子2
- public class TestRegularExperssion {
- public void printA(float a,float b)throws NullPointerException
- {
- }
- }
- class TestRegularExpressionA extends TestRegularExperssion
- {
- public void printA(float a,float b)throws SQLException
- {
- }
- } //编译不通过

异常处理十大黄金准则

1. 异常声明是API契约的一部分
受检异常（Checked Exceptions）应视为方法签名的重要组成部分，明确告知调用方可能发生的错误场景。

2. 优先使用条件测试替代异常捕获
对于可预见的常规控制流（如空值检查、状态验证），应使用if-else而非try-catch。

3. 避免过度细化的异常捕获
同一逻辑层级的异常应合并处理，避免碎片化catch块。（FileNotFoundException vs. PermissionDeniedException）

4. 合理利用异常层次结构
根据业务场景选择最匹配的异常类型：
  内置异常：优先使用IllegalArgumentException而非通用的RuntimeException。
  自定义异常：继承Exception或RuntimeException建立业务专属异常树。

5. 精确化运行时异常
避免直接抛出RuntimeException，应选择或自定义更具体的子类。

异常处理十大黄金准则

6. 禁止异常压制（Swallowing Exceptions）
捕获异常后至少需记录日志，禁止空的catch块。

7. 严格错误检测原则
对输入参数和状态检查应"严进严出"，尽早暴露问题。

8. 抛出语义明确的异常
在错误源头抛出具有业务含义的异常，避免传递底层非语义化异常。

对比：
  好：throw new EmptyStackException("Cannot pop empty stack")
  差：允许抛出NullPointerException

9. 合理传递异常
当当前层级无法处理异常时，应向上层传递而非强行捕获。

10. 早抛出，晚捕获（Throw Early, Catch Late）
在检测到错误的最早时机抛出异常。
在具备完整上下文信息的最高合适层级处理异常。

创建自己的异常

- 精心设计异常的层次结构
- 异常类中包含足够的信息
- 异常与错误提示

代码清单 **1-6** 使用异常包装技术的示例

```
public class DataAccessGateway {
    public void load() throws DataAccessException {
        try {
            FileInputStream input = new FileInputStream("data.txt");


            }
            catch (IOException e) {
                throw new DataAccessException(e);
            }
        }
    }
```

异常的消失

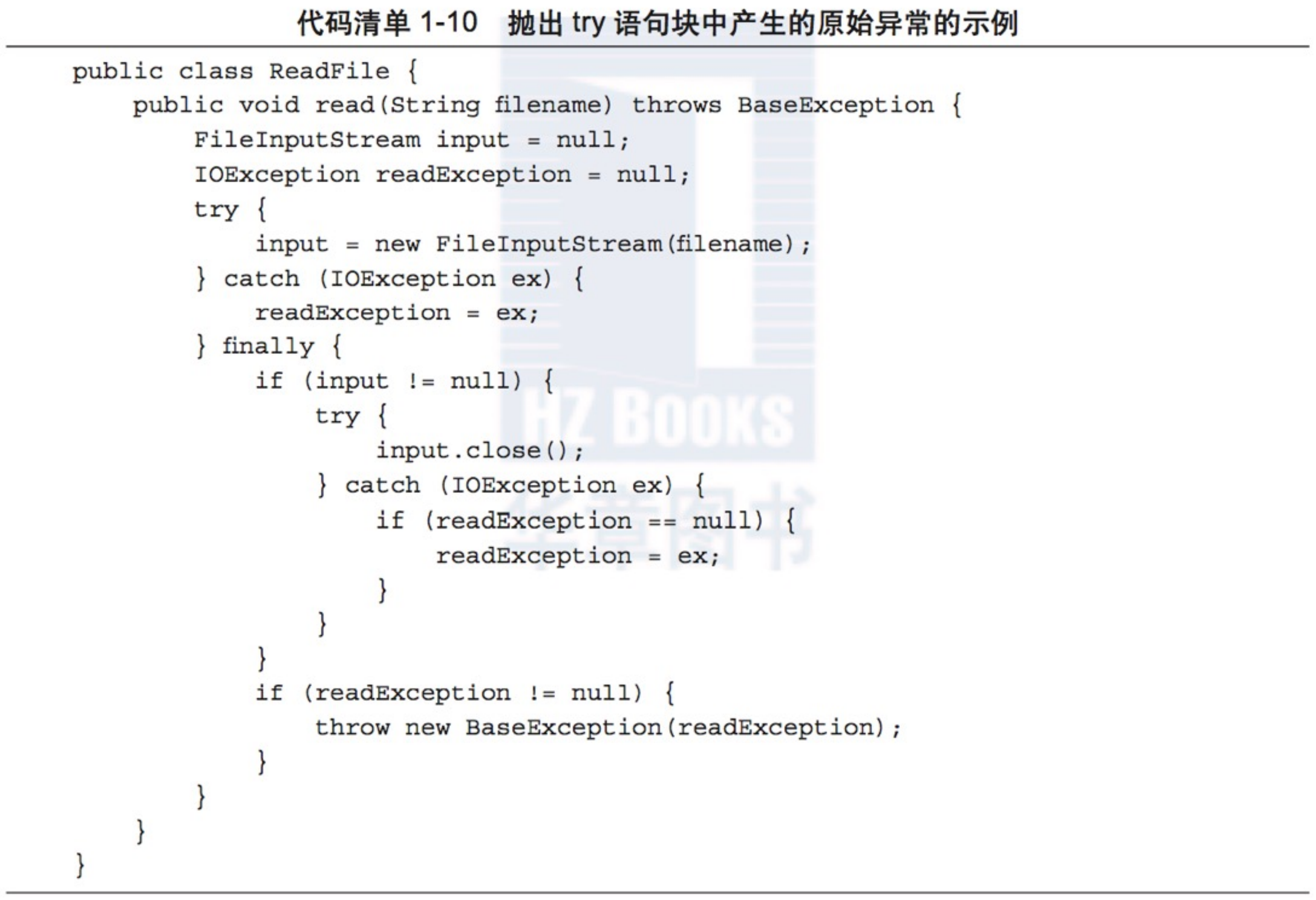
代码清单 1-9　异常消失的示例

```
public class DisappearedException {
    public void show() throws BaseException{
        try {
            Integer.parseInt("Hello");
        }
        catch (NumberFormatException nfe) {
            throw new BaseException(nfe);
        } finally {
            try {
                int result = 2 / 0;
            } catch (ArithmeticException ae) {
                throw new BaseException(ae);
            }
        }
    }
}
```

两种解决办法

- Solution 1
  - 抛出try语句块中阐述的原始异常，忽略在finally语句块中产生的异常
- Solution 2
  - 把产生的异常都记录下来

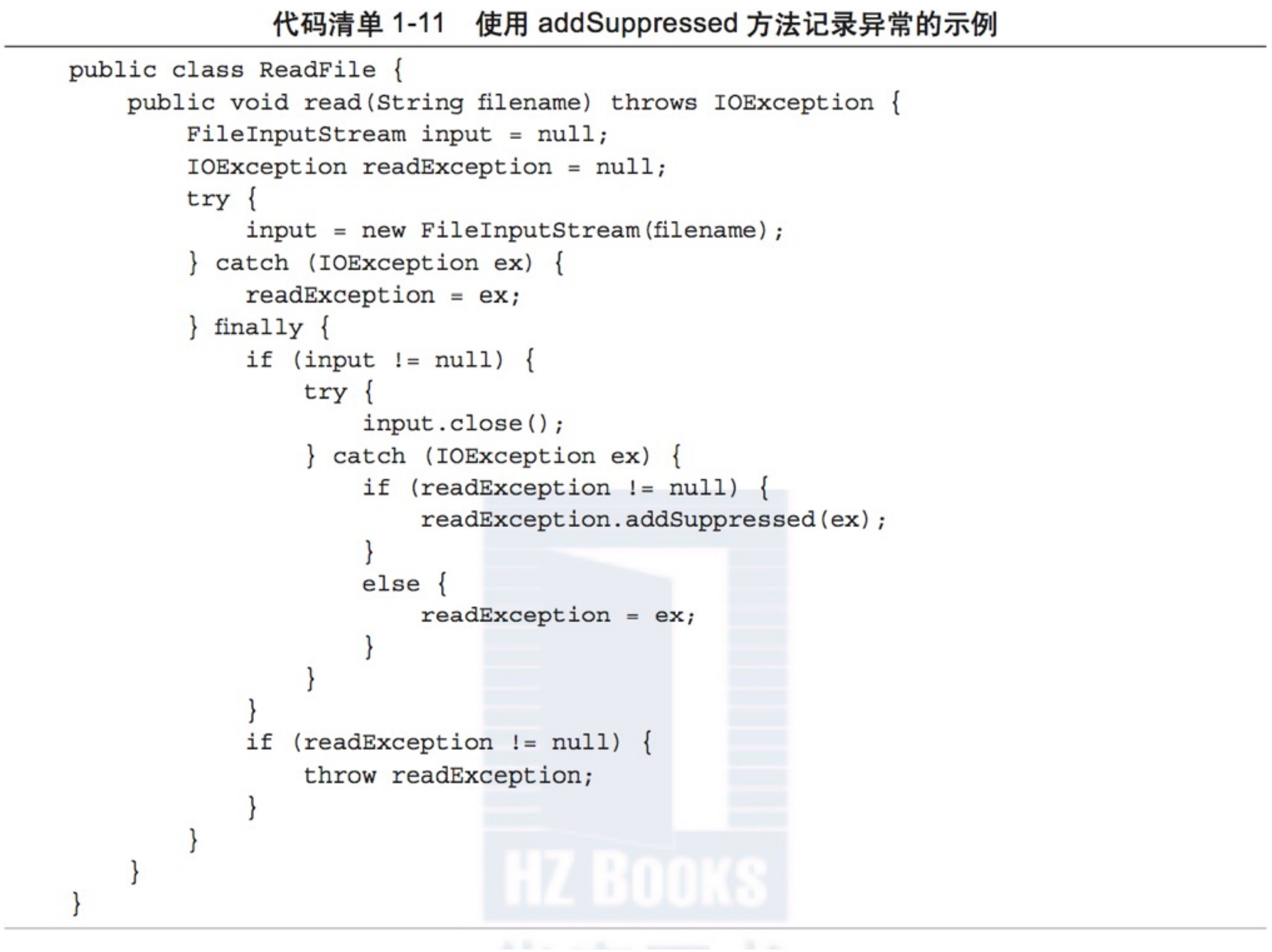
Solution 1



代码清单 1-10　抛出 try 语句块中产生的原始异常的示例

```
public class ReadFile {
    public void read(String filename) throws BaseException {
        FileInputStream input = null;
        IOException readException = null;
        try {
            input = new FileInputStream(filename);
        } catch (IOException ex) {
            readException = ex;
        } finally {
            if (input != null) {
                try {
                    input.close();
                } catch (IOException ex) {
                    if (readException == null) {
                        readException = ex;
                    }
                }
            }
            if (readException != null) {
                throw new BaseException(readException);
            }
        }
    }
}
```

Solution 2



代码清单 1-11　使用 addSuppressed 方法记录异常的示例

```java
public class ReadFile {
    public void read(String filename) throws IOException {
        FileInputStream input = null;
        IOException readException = null;
        try {
            input = new FileInputStream(filename);
        } catch (IOException ex) {
            readException = ex;
        } finally {
            if (input != null) {
                try {
                    input.close();
                } catch (IOException ex) {
                    if (readException != null) {
                        readException.addSuppressed(ex);
                    }
                    else {
                        readException = ex;
                    }
                }
            }
            if (readException != null) {
                throw readException;
            }
        }
    }
}
```

Java 7的异常处理新特性

- 一个catch子句捕获多个异常
- 更加精确的异常抛出

代码清单 1-12　在 catch 子句中指定多种异常

```java
public class ExceptionHandler {
    public void handle() {
        ExceptionThrower thrower = new ExceptionThrower();
        try {
            thrower.manyExceptions();
        } catch (ExceptionA | ExceptionB ab) {
        } catch (ExceptionC c) {
        }
    }
}
```

每个异常类型之间使用“|”来分隔

注意：
在 catch 子句中声明捕获的这些异常类，不能出现重复的类型，也不允许其中的某个异常是另外一个异常的子类，否则会出现编译错误。

代码清单 1-17　精确的异常抛出的示例

```
public class PreciseThrowUse {
    public void testThrow() throws ExceptionA {
        try {
            throw new ExceptionASub2();
        }
        catch(ExceptionA e) {
            try {
                throw e;
            }
            catch (ExceptionASub1 e2) { //编译错误

            }
        }
    }
}
```

在上面的代码中,异常类 ExceptionASub1 和 ExceptionASub2 都是 ExceptionA 的子类。方法 testThrow 中首先抛出了 ExceptionASub2 异常,通过第一个 catch 子句捕获之后重新抛出。在这里,Java 编译器可以准确知道变量 e 表示的异常类型是 ExceptionASub2,接下来的第二个 catch 子句试图捕获 ExceptionASub1 类型的异常,这显然是不可能的,因此会产生编译错误。上面的代码在 Java 6 编译器上是可以通过编译的。对于 Java 6 编译器来说,第二个 try 子句中抛出的 异常类型是前一个 catch 子句中声明的 ExceptionA 类型,因此在第二个 catch 子句中尝试捕获 ExceptionA 的子类型 ExceptionASub1 是合法的。

Java 7中引入try-with-resources语句

代码清单 1-18　读取磁盘文件内容的示例

```java
public class ResourceBasicUsage {
    public String readFile(String path) throws IOException {
        try (BufferedReader reader = new BufferedReader(new FileReader(path))) {
            StringBuilder builder = new StringBuilder();
            String line = null;
            while ((line = reader.readLine()) != null) {
                builder.append(line);
                builder.append(String.format("%n"));
            }
            return builder.toString();
        }
    }
}
```

代码清单 1-19　自定义资源使用 AutoCloseable 接口的示例

```
public class CustomResource implements AutoCloseable {
    public void close() throws Exception {
        System.out.println("进行资源释放。");
    }

    public void useCustomResource() throws Exception {
        try (CustomResource resource = new CustomResource())  {
            System.out.println("使用资源。");
        }
    }
}
```

能够被 try 语句所管理的资源需要满足一个条件,那就是其 Java 类要实现 java.lang. AutoCloseable 接口,否则会出现编译错误。当需要释放资源的时候,该接口的 close 方 法会被自动调用。Java 类库中已有不少接口或类继承或实现了这个接口,使得它们可 以用在 try 语句中。在这些已有的常见接口或类中,最常用的就是与 I/O 操作和数据库相关的接口。与 I/O 相关的 java.io.Closeable 继承了 AutoCloseable,而与数据库相关的 java.sql.Connection、java.sql.ResultSet 和 java.sql.Statement 也继承了该接口。如果希望自己开发的类也能利用 try 语句的自动化资源管理,只需要实现 AutoCloseable 接口即可。

代码清单 1-20　使用 try-with-resources 语句管理两个资源的示例

```
public class MultipleResourcesUsage {
    public void copyFile(String fromPath, String toPath) throws IOException {
        try (InputStream input = new FileInputStream(fromPath);
                OutputStream output = new FileOutputStream(toPath)) {
            byte[] buffer = new byte[8192];
            int len = -1;
            while ((len = input.read(buffer)) != -1) {
                output.write(buffer, 0, len);
            }
        }
    }
}
```

当finally子句包含return 语句

```
public class MyExceptionExample{

    public static int f(int n){
        int r;
        try{
            r = n*n;
            return r;
        }
        finally{
            r =2;
            return r;
        }
    }
    public static void main(String[] args){
        System.out.println(f(2));
    }
}
```

athrow指令

- throw语句
  - 由athrow指令实现
    - new java/io/IOException // 创建异常对象
    - dup // 复制栈顶（供构造函数使用）
    - invokespecial java/io/IOException/<init>()V // 调用构造函数
    - athrow // 抛出异常

- idiv或ldiv指令中抛出ArithmeticException

```
promote:~ qinliu$ javap -verbose MyExceptionExample
Classfile /Users/qinliu/MyExceptionExample.class
  Last modified 2015-5-27; size 425 bytes
  MD5 checksum 1b6dbb4173666b6fb0eb54381864e541
  Compiled from "MyExceptionExample.java"
public class MyExceptionExample
  minor version: 0
  major version: 52
  flags: ACC_PUBLIC, ACC_SUPER
Constant pool:
   #1 = Methodref          #4.#16         //
java/lang/Object."<init>":()V
   #2 = Class              #17            // java/lang/Exception
   #3 = Class              #18            // MyExceptionExample
   #4 = Class              #19            // java/lang/Object
   #5 = Utf8               <init>
   #6 = Utf8               ()V
   #7 = Utf8               Code
   #8 = Utf8               LineNumberTable
   #9 = Utf8               inc
  #10 = Utf8               ()I
  #11 = Utf8               StackMapTable
  #12 = Class              #17            // java/lang/Exception
  #13 = Class              #20            // java/lang/Throwable
  #14 = Utf8               SourceFile
  #15 = Utf8               MyExceptionExample.java
  #16 = NameAndType        #5:#6          // "<init>":()V
  #17 = Utf8               java/lang/Exception
  #18 = Utf8               MyExceptionExample
  #19 = Utf8               java/lang/Object
  #20 = Utf8               java/lang/Throwable
{
  public MyExceptionExample();
    descriptor: ()V
    flags: ACC_PUBLIC
    Code:
      stack=1, locals=1, args_size=1
         0: aload_0
         1: invokespecial #1                  // Method
java/lang/Object."<init>":()V
         4: return
      LineNumberTable:
        line 1: 0

  public int inc();
    descriptor: ()I
    flags: ACC_PUBLIC
    Code:
      stack=1, locals=5, args_size=1
         0: iconst_1
         1: istore_1
         2: iload_1
         3: istore_2
         4: iconst_3
         5: istore_1
         6: iload_2
         7: ireturn
         8: astore_2
         9: iconst_2
        10: istore_1
        11: iload_1
        12: istore_3
        13: iconst_3
        14: istore_1
        15: iload_3
        16: ireturn
        17: astore        4
        19: iconst_3
        20: istore_1
        21: aload         4
        23: athrow
      Exception table:
         from    to  target type
             0     4     8   Class java/lang/Exception
             0     4    17   any
             8    13    17   any
            17    19    17   any
      LineNumberTable:
        line 5: 0
        line 6: 2
        line 12: 4
        line 7: 8
        line 8: 9
        line 9: 11
        line 12: 13
      StackMapTable: number_of_entries = 2
        frame_type = 72 /* same_locals_1_stack_item */
          stack = [ class java/lang/Exception ]
        frame_type = 72 /* same_locals_1_stack_item */
          stack = [ class java/lang/Throwable ]
}
SourceFile: "MyExceptionExample.java"
```

```
1.  public class MyExceptionExample{
2.      public int inc(){
3.          int x;
4.          try{
5.              x=1;
6.              return x;
7.          }catch(Exception e){
8.              x=2;
9.              return x;
10.         }
11.         finally{
12.             x=3;
13.         }
14.     }
15.}
```

下面代码的输出结果是什么？

catch中抛出异常

```
public static void main(String[] args) {
        try {
            int i = 100 / 0;
            System.out.print(i);
        } catch (Exception e) {
            System.out.print(1);
            throw new RuntimeException();
        } finally {
            System.out.print(2);
        }
        System.out.print(3);
    }
```

在catch中又抛出了异常，这时除了执行finally中的代码，往下的代码都不会执行了。