# 1 Introduction to Compilers (Continued)

We'll be using s-expressions to represent our program's source code. That is, each `snek` file will contain s-expressions. S-expressions are defined as either

- An **atom** of the form $x$, or
- An **expression** of the form $(x \quad y)$, where $x$ and $y$ are s-expressions.

For example, `(sub1 2)` is an expression with two atoms, `sub1` and `2`.

## 1.1 The `sexp` Crate

Most programming language will have a parser for s-expressions. In Rust, we have the `sexp` crate. This crate has the following `enums`[1]:

- A `Sexp` enum, representing either an `Atom` or a vector of s-expressions. Vectors of s-expressions will contain two elements (since an expression has the form $(x \quad y)$, which has two expressions).

```
pub enum Sexp {
    Atom(Atom),
    List(Vec<Sexp>),
}
```

- An `Atom` enum, representing one of three different types of atoms: a `String`, `i64` (64-bit signed integer), or `f64` (double-precision float).

```
pub enum Atom {
    S(String),
    I(i64),
    F(f64)
}
```

(Exercise.) Why is `Vec<Box<Sexp>>` or `Box<Vec<Sexp>>` not used in the `enum` definitions above?

Remember that the reason why something like

```
enum Expr {
    Num(i32),
    Add1(Expr),
    Sub1(Expr)
}
```

wouldn't work is because `Expr`, as a recursive type, could have infinite size. That is, we could nest *many* `Expr`s, and since this value could theoretically continue infinitely, so we don't know how much space this recursive type needs. However, `Box<T>` is a pointer type that allocates memory on the heap. `Box<T>` has a *fixed* size, so Rust is fine if we have `Box<Expr>`.

The reason why we *don't* need `Vec<Box<Sexpr>>` or `Box<Vec<Sexpr>>` in the above `enums` is because `Vec<T>` allocates to the heap (when you add any elements; a vector created initially with no elements does not allocate). In other words, think of `Vec<T>` as being a resizable `Box<T>`. More accurately, a `Vec<T>` is a fixed-size type with a reference to variable-sized heap data.

[1] In Rust, `enums` are algebraic data types.

(Exercise.) Represent the following s-expression in Rust:

```
(sub1 (sub1 (add1 73)))
```

First, the s-expression itself is roughly similar to a tree, where each *atom* is a leaf node and each *list* is another s-expression. In any case, we can roughly structure the above s-expression like so:

```
(               // List
    sub1            // Atom
    (               // List
        sub1            // Atom
        (               // List
            add1            // Atom
            73              // Atom
        )
    )
)
```

In other words, we have a list whose elements are an *atom* and another *list*. With this in mind, the Rust form is

```
List(vec![
    Atom(S("sub1")),
    List(vec![
        Atom(S("sub1")),
        List(vec![
            Atom(S("add1")),
            Atom(I(73))
        ])
    ])
])
```