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Learning F# on the job as a programming novice

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demetrixbio.com

We make nature’s rarest ingredients **accessible**, **sustainable** and **affordable** for *happier, healthier lives.*

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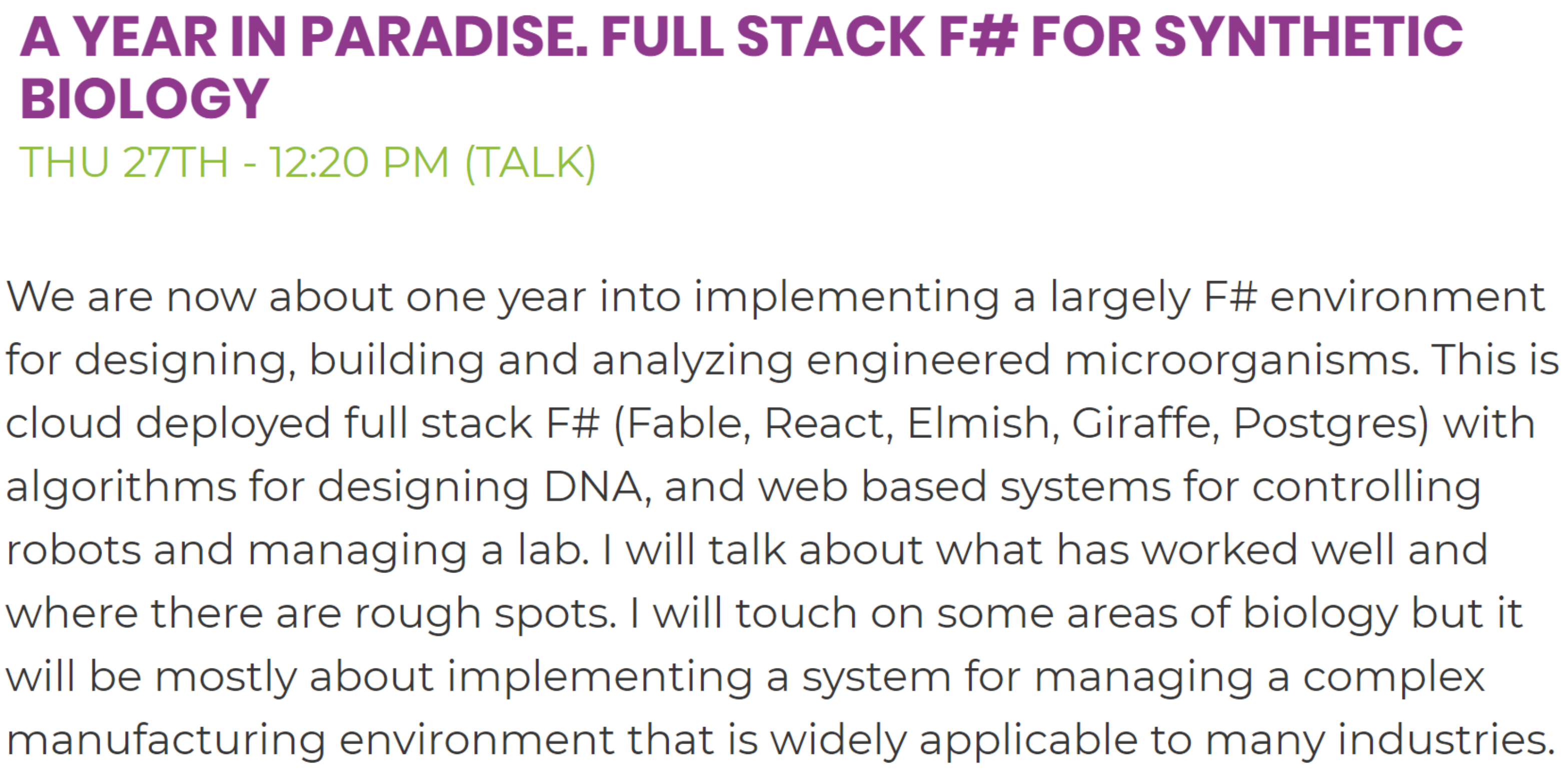
Demetrix takes DNA sequences from plants and puts them in to yeast – yeast now makes what the plant does

Click to add text

Last year…



A YEAR IN PARADISE. FULL STACK F# FOR SYNTHETIC BIOLOGY

THU 27TH - 12:20 PM (TALK)

We are now about one year into implementing a largely F# environment for designing, building and analyzing engineered microorganisms. This is cloud deployed full stack F# (Fable, React, Elmish, Giraffe, Postgres) with algorithms for designing DNA, and web based systems for controlling robots and managing a lab. I will talk about what has worked well and where there are rough spots. I will touch on some areas of biology but it will be mostly about implementing a system for managing a complex manufacturing environment that is widely applicable to many industries.

Darren Platt

Full disclosure: I am not a software developer

- I am a scientist!
- Became interested in programming when I learned Genotype Specification Language (GSL)
- I’ve been (slowly) learning F# for the past 2 years
- If I say something dumb, please be nice

Our LIMS software supports a complex laboratory environment

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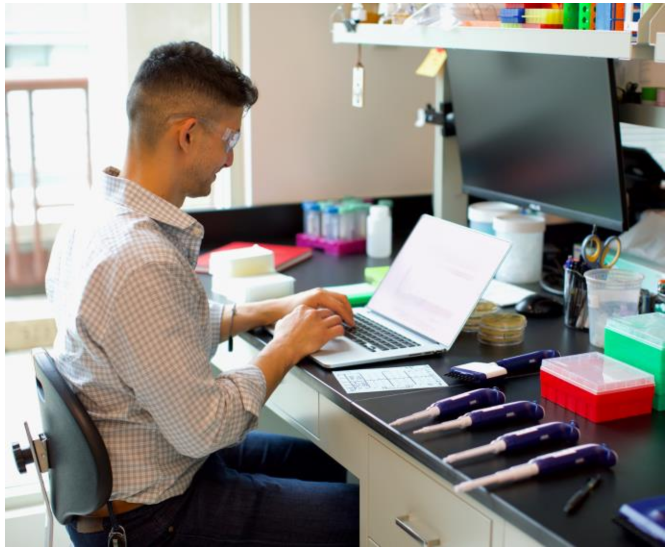
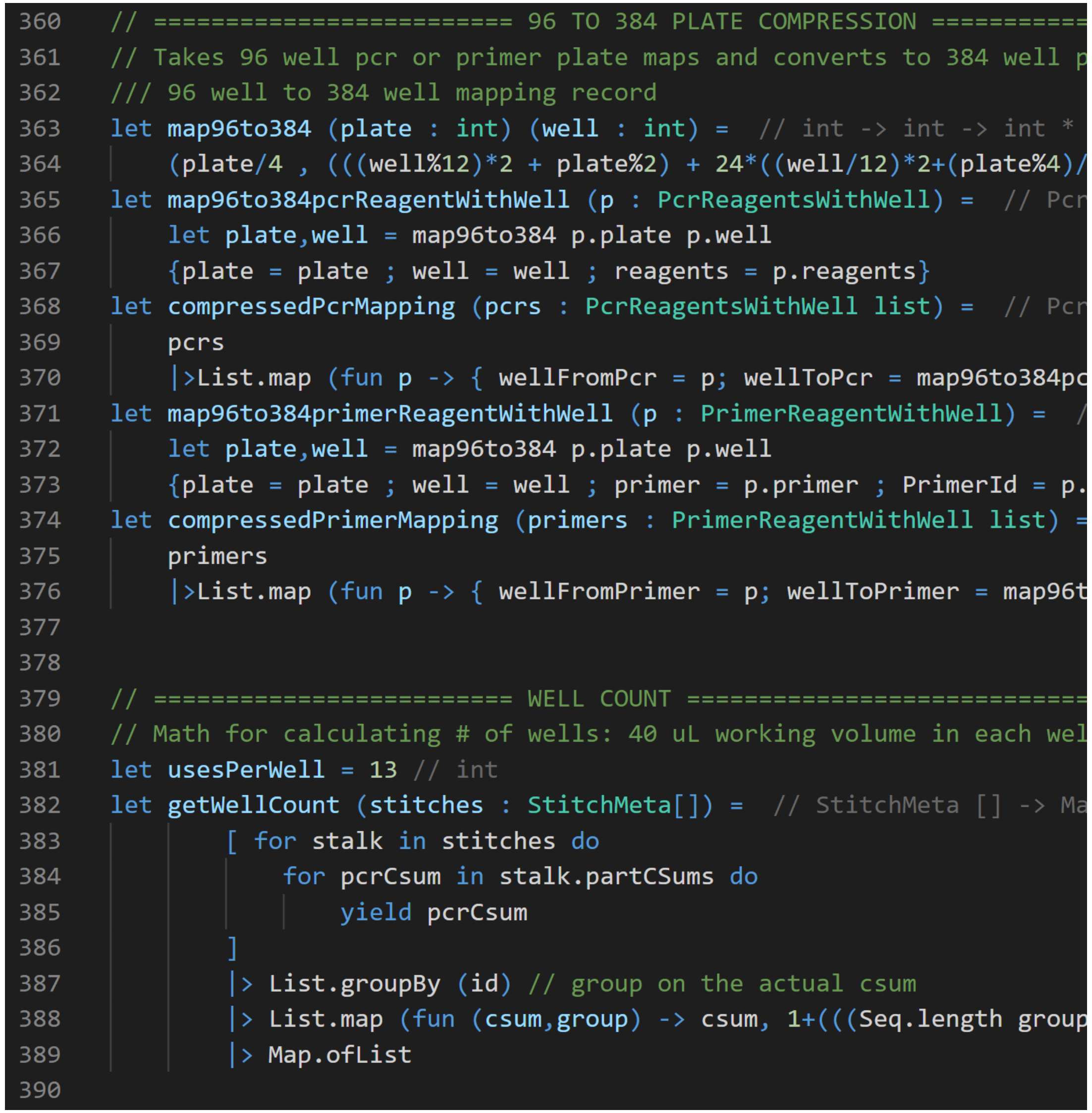
We have novice F# developers across many areas of expertise



- Represented: cell and molecular biology, chemical engineering, analytical chemistry, automation engineering, fermentation science
- Knowledge transfer between developers and users is sped up when we speak each other’s languages.

Non-developers have made meaningful contributions to Demetrix software

- Robot worklists
- Data processing and analysis
- Label printing
- Data visualization
- DNA design visualizations
- < 3% of our commits were authored by non-developers



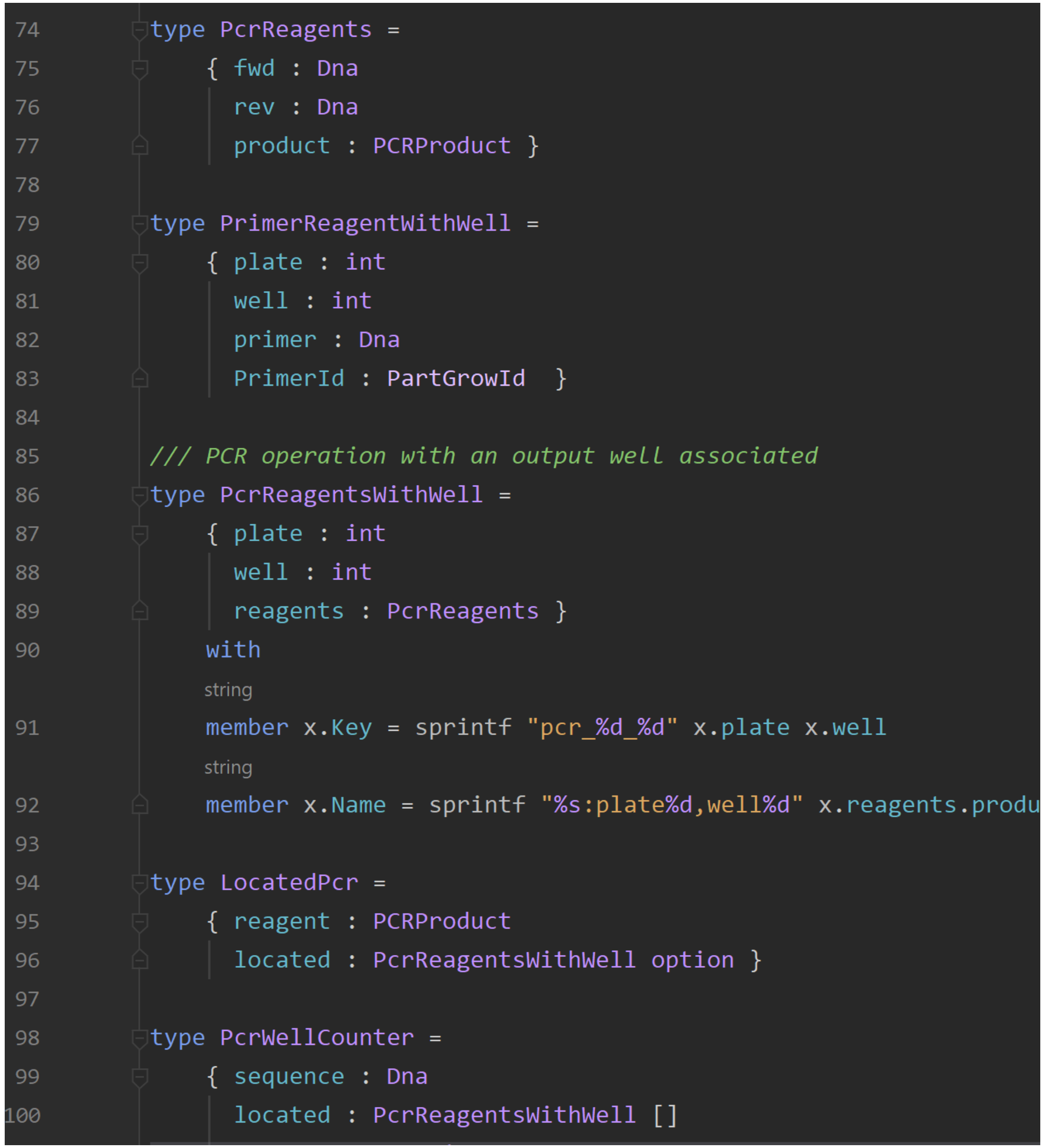
```
// ======================== 96 TO 384 PLATE COMPRESSION ==========
// Takes 96 well pcr or primer plate maps and converts to 384 well p
/// 96 well to 384 well mapping record
let map96to384 (plate : int) (well : int) =  // int -> int -> int *
    (plate/4 , (((well%12)*2 + plate%2) + 24*((well/12)*2+(plate%4)/
let map96to384pcrReagentWithWell (p : PcrReagentsWithWell) =  // Pcr
    let plate,well = map96to384 p.plate p.well
    {plate = plate ; well = well ; reagents = p.reagents}
let compressedPcrMapping (pcrs : PcrReagentsWithWell list) =  // Pcr
    pcrs
    |>List.map (fun p -> { wellFromPcr = p; wellToPcr = map96to384pc
let map96to384primerReagentWithWell (p : PrimerReagentWithWell) =  /
    let plate,well = map96to384 p.plate p.well
    {plate = plate ; well = well ; primer = p.primer ; PrimerId = p.
let compressedPrimerMapping (primers : PrimerReagentWithWell list) =
    primers
    |>List.map (fun p -> { wellFromPrimer = p; wellToPrimer = map96t


// ======================== WELL COUNT ==========================
// Math for calculating # of wells: 40 uL working volume in each wel
let usesPerWell = 13 // int
let getWellCount (stitches : StitchMeta[]) =  // StitchMeta [] -> Ma
        [ for stalk in stitches do
          for pcrCsum in stalk.partCSums do
            yield pcrCsum
        ]
        |> List.groupBy (id) // group on the actual csum
        |> List.map (fun (csum,group) -> csum, 1+(((Seq.length group
        |> Map.ofList

```

About us

- 0 – 2 years experience
- Most of us spend only a few hours per week on software
- Most people characterize themselves as having beginner or intermediate programming skills
- Previous experience includes: Python, R, Matlab, SQL, Java

Successes: Things that help novices

- Types and type inference!
- Functional programming can be intuitive for scientists dealing with lab processes and data science
- Units!
- Supportive community, learning resources are steadily improving



```
type PcrReagents =
    { fwd : Dna
      rev : Dna
      product : PCRProduct }

type PrimerReagentWithWell =
    { plate : int
      well : int
      primer : Dna
      PrimerId : PartGrowId  }

/// PCR operation with an output well associated
type PcrReagentsWithWell =
    { plate : int
      well : int
      reagents : PcrReagents }
    with
    string
    member x.Key = sprintf "pcr_%d_%d" x.plate x.well
    string
    member x.Name = sprintf "%s:plate%d,well%d" x.reagents.produ

type LocatedPcr =
    { reagent : PCRProduct
      located : PcrReagentsWithWell option }

type PcrWellCounter =
    { sequence : Dna
      located : PcrReagentsWithWell []
```

Challenges: Things that are hard for novices

- Getting set up and getting started
  - Lack of consistent documentation
  - Package dependencies and set up
  - Out of the box scripting experience is more difficult than other commonly used languages (i.e. Python/Jupyter)
- Limited examples and help on StackOverflow and elsewhere
  - Data science, bioinformatics, statistics
- Language independent challenge – it’s hard to keep up with the changes in a large software project when you only contribute occasionally

Opportunities: Things that would help more people learn F#

- More introductory materials for non-developers
- A “go-to” place for getting started, installing and using packages, type providers
- More examples of scientific applications (i.e. common data processing and statistics)

Resources we’ve been using:

- Open F# Workshops!
- Self-teaching
- Microsoft F# documentation
- Fsharpforfunandprofit.com
- Studying code examples
- Direct instruction from co-workers
- StackOverflow
- Fsharp.tv
- Fsharp.org
- Books, videos

Conclusions

- Novices learning F# helps bridge the gap between developers and non-developers by helping us speak each other’s languages
- The activation energy for a novice to learn F# is high, but it’s getting better
- Novices can make meaningful contributions to software by implementing domain expertise in code

Thank you

- Open F# Team, particularly Gien Verschatse
- Demetrix Software Developers: Garrett Birkel, Gien Verschatse, Marcell Legeza, Max Grebeniuk, Alfonso Garcia-Caro, Olya Samusik
- Darren Platt

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