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# Evolving Open Complexity

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W. B. Langdon, UCL

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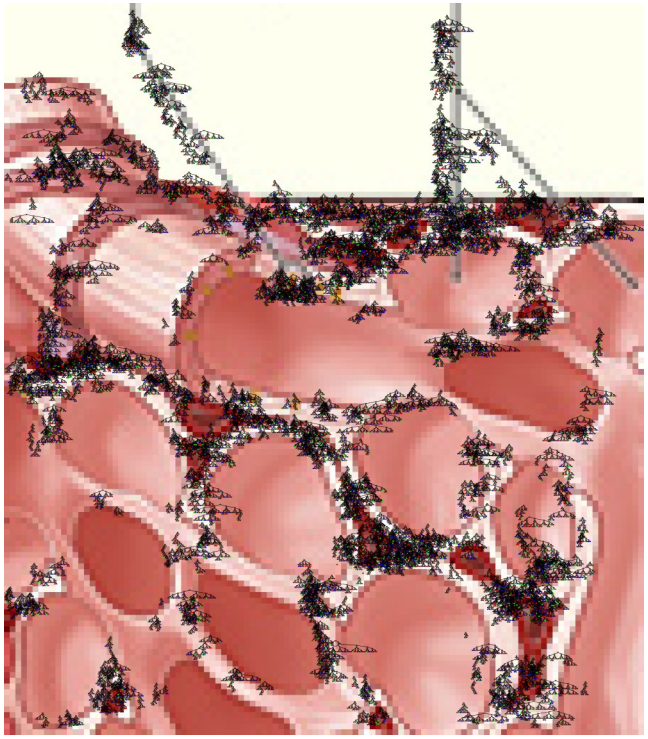
Information theory suggests for most deeply nested mutations disruption fails to propagate to the output.

Instead suggest lung like open architecture where most code is less than seven levels from the environment.

arXiv:2112.00812

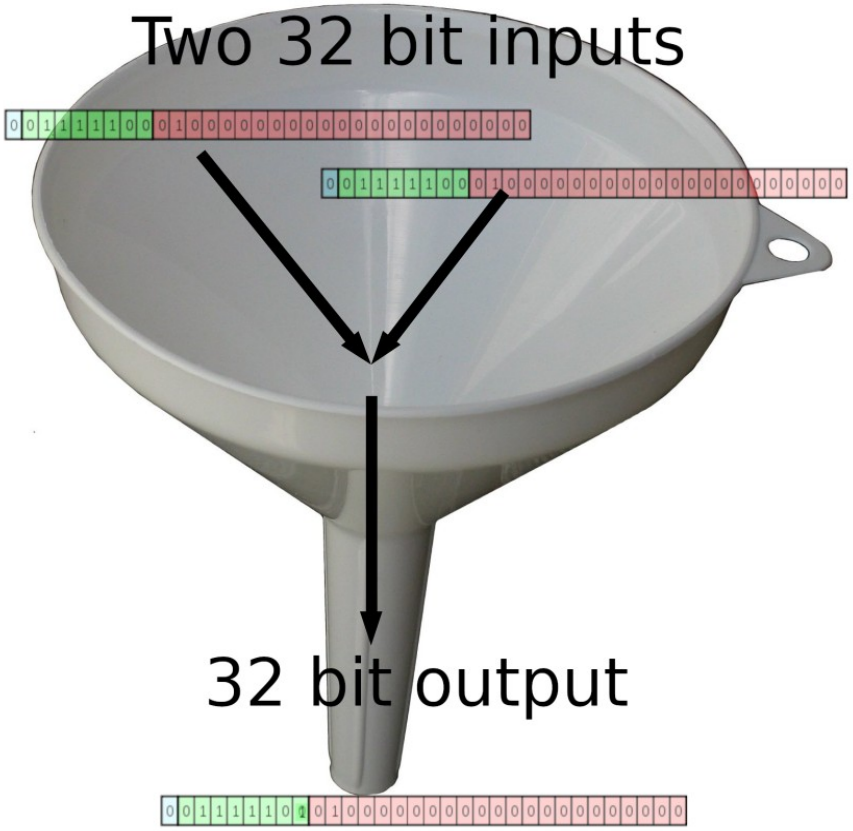


# Long Term Evolution Experiments v. Artificial Evolution

- Information theory predicts nested functions (eg + * - /) will fail to propagate disruption.
- **LTEE** shows E.Coli continued innovation 75000 generations
- Genetic Programming continued fitness improvement a million generations BUT GP slows
  - Impact of mutations lost, mostly due to rounding error
  - In deep integer trees 92% to 99.97% of evaluation changes have no effect
- Exponential decay with depth
  - Need to be close to error for tests to find them
  - On average <7 more than 50% errors detected
- Conclude need shallow open architecture to evolve complexity

# Information Funnel

Computer operators are irreversible. Meaning input state cannot be inferred from outputs. Information is lost

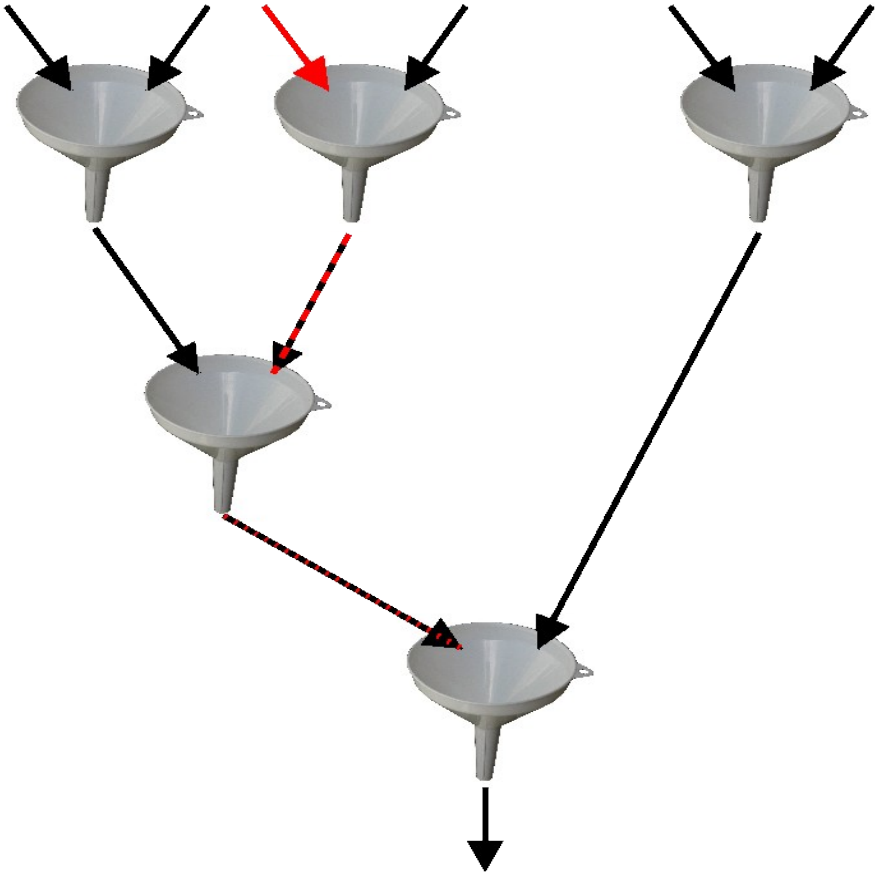



**Information funnel**

More information enters than leaves

# Information flow in five nested functions

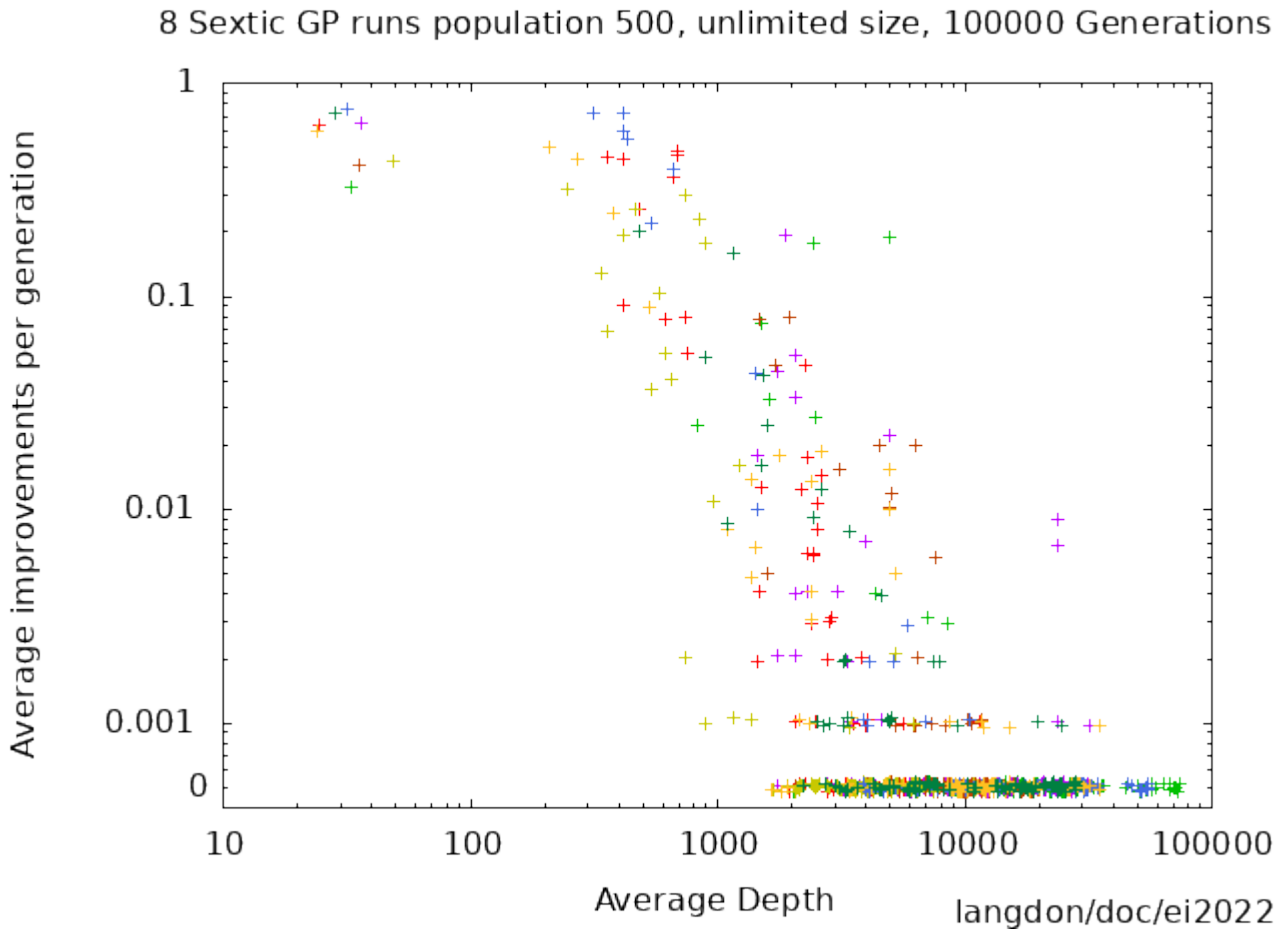
Potential information loss at each (irreversible) function




Disruption may fail to reach reach output.

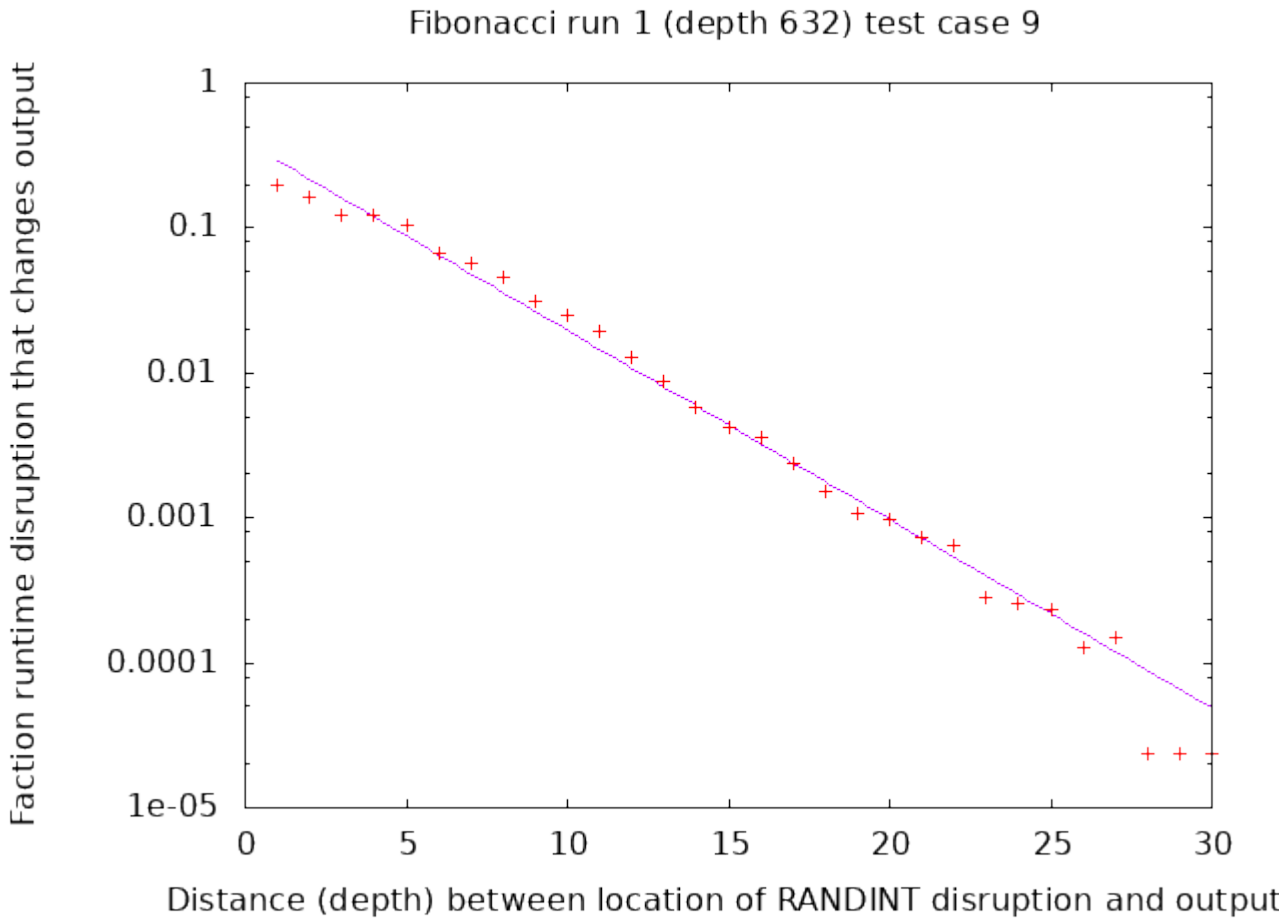
(No side effects.)

# Deeper programs harder to evolve




As the GP populations evolve they find thousands of improvements but at a slower rate as the trees get deeper. Note log scales.

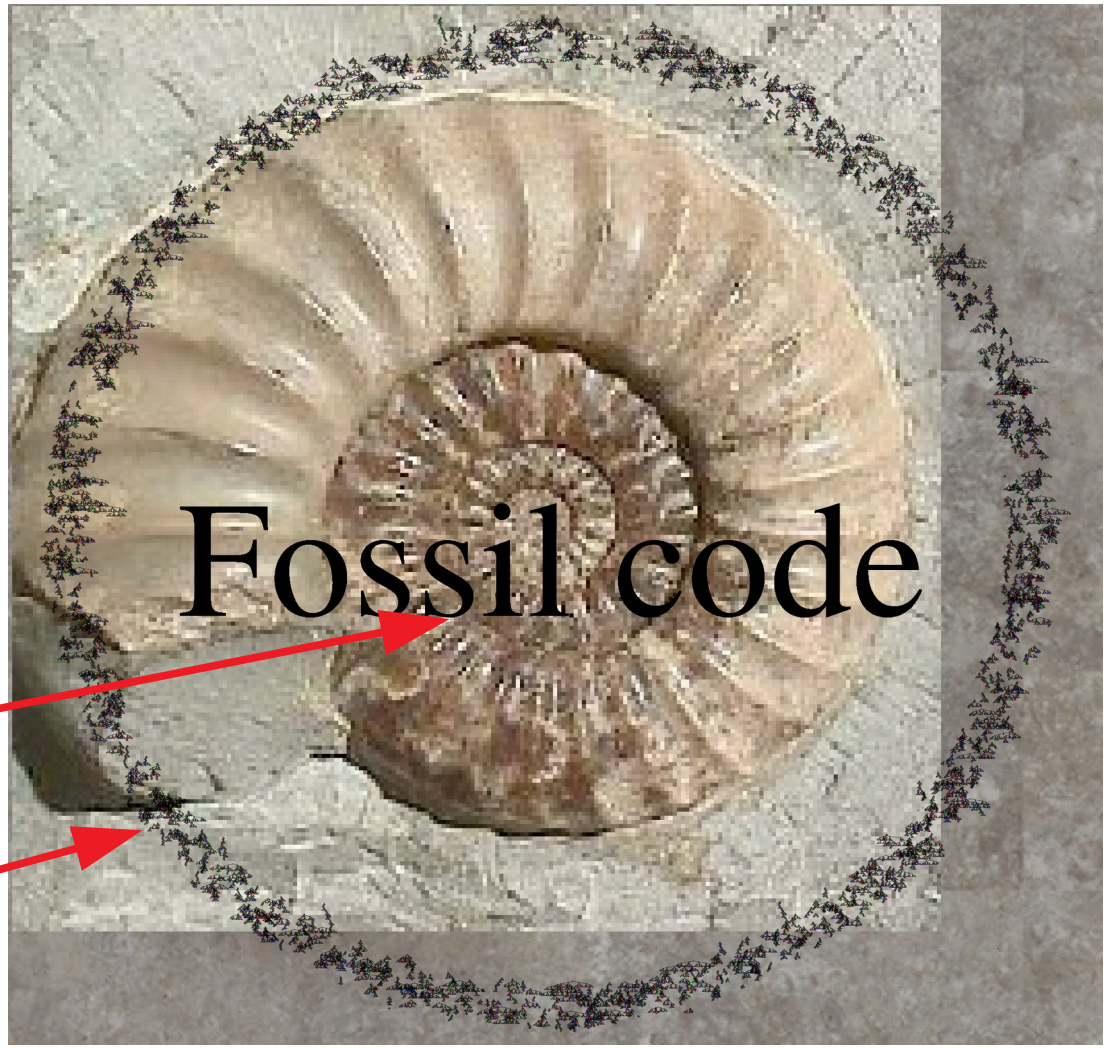
# Exponential fall in fraction of run time disruption changing program output with depth




Perturb evaluation of deep evolved Fibonacci program. Replacement with random value seldom has externally visible impact. Note log vertical scale.

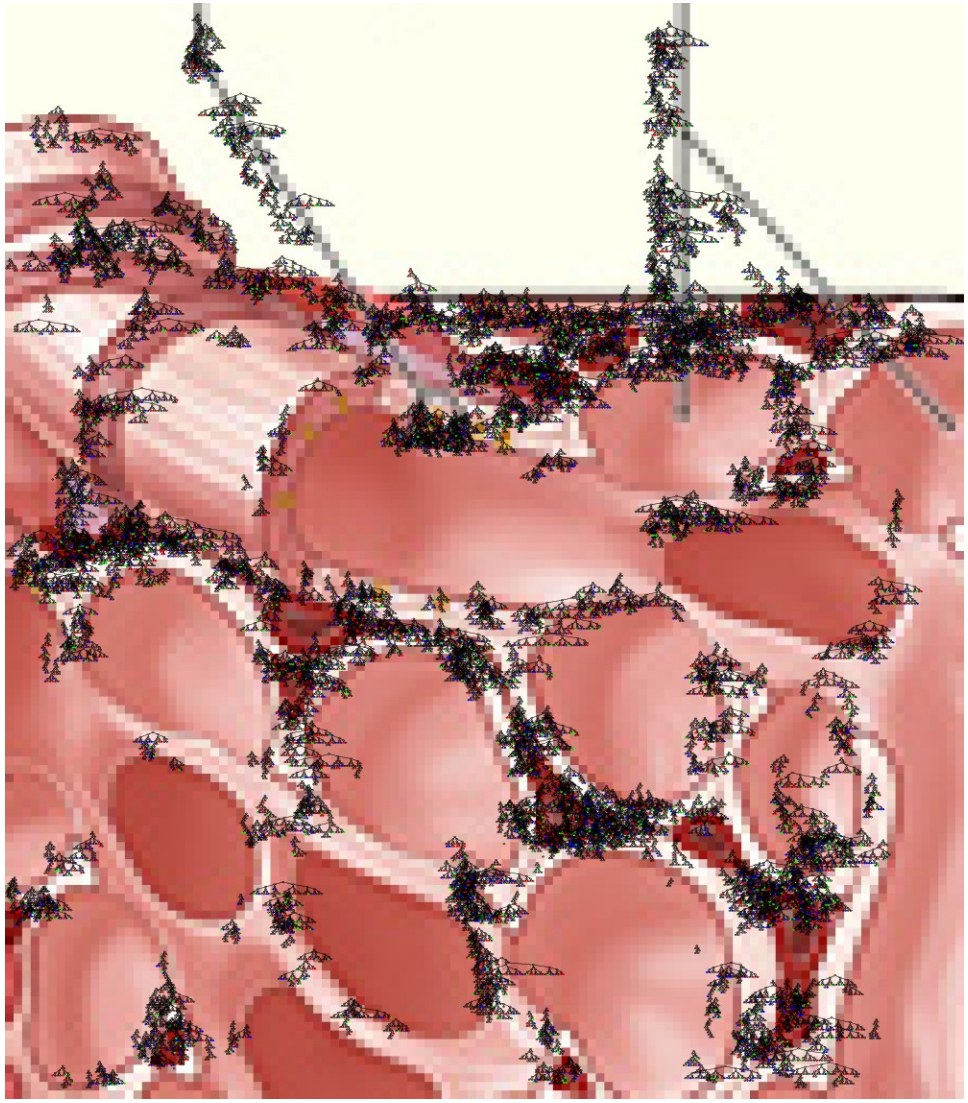
# To evolve large complex code, Must **AVOID** large fossil of dead code

- With **deep code** most crossovers and mutations make **no difference**.
- Leading to random drift
- Not directed evolution
- To avoid dead center evolving code must be near environment.



# Evolve Large Open, Lung Like, Open Architecture

- Make code is shallow.
- Shallow code does not suffer failed disruption propagation.
- Instead fitness disruption caused by mutations and crossover do have impact.
- Fitness can direct evolution.
- Suggest large porous code
- All code near organism's environment.
- Communication between code internally & externally eased by globals, side effects, pipes, TCP/IP etc.

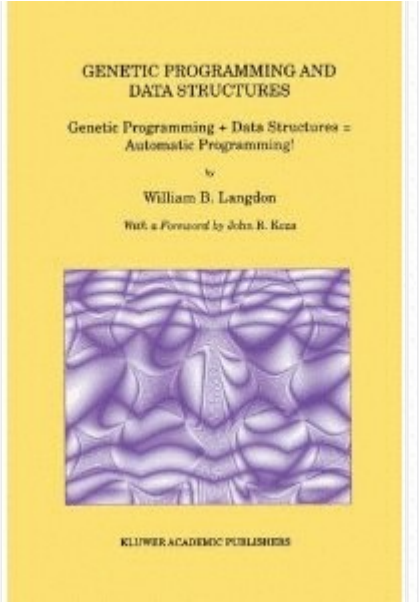


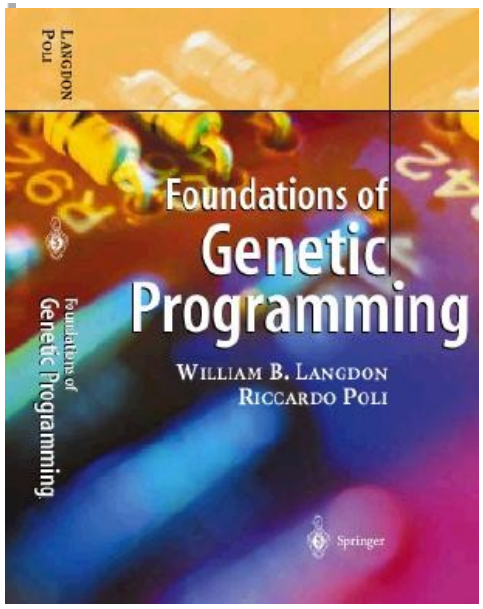
# Evolve **Open** Complexity

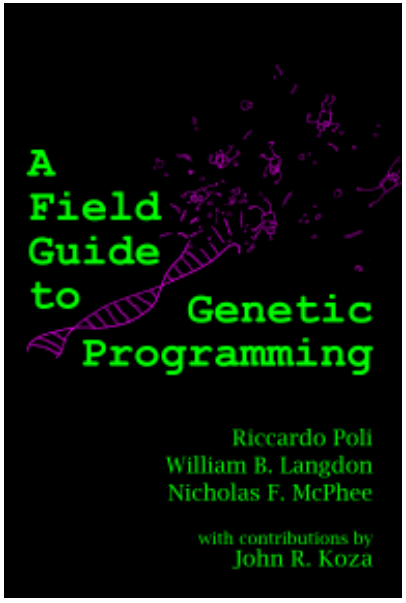
1) Information theory predicts, without side effects, nested irreversible computation will loose information and so
2) nested expressions suffer failed disruption propagation.
3) Meaning impact of deep code changes does not reach output
4) **Deep mutations do not change fitness**
5) Without fitness changes there is no evolution
6) To avoid code fossilising, changes must impact performance
7) To **evolve** code it must be **shallow**, close to environment
8) Open porous lung like code, possibly in many dimensions, with open channels between shallow <7 code modules

# Genetic Programming

## W. B. Langdon



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# The Genetic Programming Bibliography

**15405** references, 15000 authors

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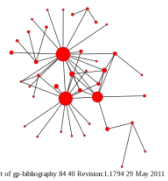

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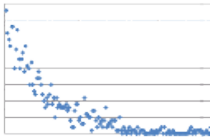

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