



GenoCAD Introduction





Computer-Assisted Design Software
for Synthetic Biology

Materials prepared by:
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www.openhelix.com/genocad



Version 1






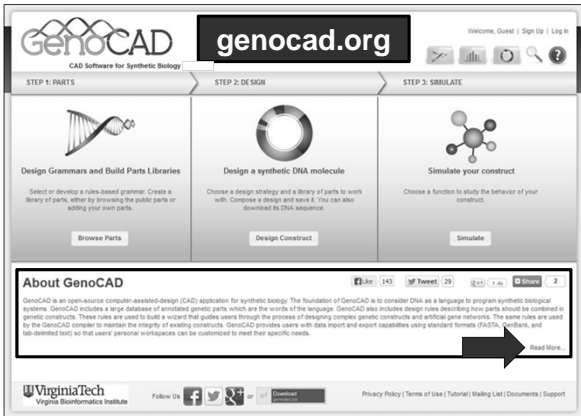
GenoCAD Introduction Agenda

- Introduction and Credits
- Register and Log In
- Step 1: Parts
 - Parts
 - Grammar
 - Import the Training Set
- Step 2: Design
- Step 3: Simulate
- Summary
- Exercises

GenoCAD: <http://www.genocad.org/>



Introduction to GenoCAD



The screenshot shows the GenoCAD website with a navigation bar at the top containing the logo, the URL "genocad.org", and user options like "Welcome, Guest", "Sign Up", and "Log In". Below the navigation bar are three main steps: "STEP 1: PARTS" (Design Grammars and Build Parts Libraries), "STEP 2: DESIGN" (Design a synthetic DNA molecule), and "STEP 3: SIMULATE" (Simulate your construct). Each step has a corresponding icon and a brief description of the task. At the bottom of the screenshot, there is an "About GenoCAD" section with a brief description of the software and a "Read More" link.

- Computer-assisted design software for synthetic biology
- Visit GenoCAD.org

Support for GenoCAD

What is GenoCAD™?

GenoCAD is an open-source computer-assisted-design (CAD) application for synthetic biology. The foundation of GenoCAD is to consider DNA as a language to program synthetic systems. GenoCAD includes a large database of annotated genetic parts which are the words of the language. GenoCAD also includes design rules describing how parts should be combined. These rules are used to build a virtual genome that guides users through the process of designing complex genetic constructs and artificial gene networks. The same GenoCAD compiler to maintain the integrity of existing constructs. GenoCAD provides users with data import and export capabilities using standard formats (FASTA, GenBank, etc.) so that users' personal workbooks can be customized to meet their specific needs.

Getting started

Step by Step Tutorial Documents
Technical support: Support

Who develops GenoCAD?

GenoCAD is developed by the Peccoud Lab at Virginia Bioinformatics Institute. Up-to-date information about GenoCAD is available on the website www.peccoud.org. The material is based upon work supported by the National Science Foundation (NSF) Grant IRI-0505100. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

GenoCAD Source Code

GenoCAD is distributed open source using the Apache Version 2.0 License. This license has been approved by the Open Source Initiative. The GenoCAD source code is hosted on SourceForge <http://sourceforge.net/projects/genocad/dev>.

Peccoud team

NSF support

Process Flow

Parts and grammars, public or custom collections

Design constructs

Simulate processes

Conceptual Framework for GenoCAD

Grammar rules are made of Parts of Speech

Sentence

Subject **Verb** **NounPhrase** **PrepositionalPhrase**

Rules make the framework, words make the sentence

New Design

History

Aspects of DNA function explained with language metaphors: transcription, translation, code

GenoCAD lets you develop language for programming cells

Data Model, Concepts

Promoters **Coding Seqs** **Terminators**

Grammar

Rule **Category** **Category** **Category** **Category**

Promoter A **Coding Seq A**

Promoter B **Coding Seq B**

Public Library **Personal Library** **Design** **Your constructs**

peccoud.vbi.vt.edu/publications
2007: 10.1093/bioinformatics/btm446
2009: 10.1371/journal.pcbi.1000529

Parts form the foundation, stored in project libraries

Grammar rules specify the way the parts work in series

Parts + Grammars give you synthetic construct designs

Further Reading

Genetic design automation: engineering fantasy or scientific renewal?
Matthew W. Lux¹, Brian W. Bramlett², David A. Ball¹ and Jean Peccoud^{1,3}

Publications: theoretical, software, ongoing development

Cite GenoCAD if you use the tools

Getting Assistance

- Help: context-sensitive help from ? Button
- Support link for asking questions or offering feedback
- Social media

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Register at GenoCAD

- Not required, but very handy
- Your preferences, parts and creations will be saved

Password Recovery or Reset

- If needed in the future, you can reset password easily

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Step 1: Parts

- Step 1: Exploring parts libraries and grammars
- Public parts and libraries samples are pre-loaded
- You will add other sources and your own project libraries
- Access to the pieces you need for subsequent steps

Parts and Parts Libraries

- Libraries will store the parts
- Public libraries are not editable by users
- Later we'll create and edit custom project libraries

Libraries contain Categories with Parts

Selected items will be displayed with relevant details
Choose: Promoter (PRO)

- Folder contains parts associated with a grammar

Examine a Part Category: Promoter

Parts list
PartID is unique

- A category may have multiple part items

Part Detail Features

Unique PartID
Name
sequence
Description
Only ATGC (limit: ~16 million bases)
Parts can be shared across libraries
These are the features that can be located with the "search" tool later.

- Part Detail includes important features and sequence

Search for Items

search

- Locate specific parts quickly with a search

Basic Search and My Cart

Search the parts fields to locate specific items quickly

Use * as a wildcard

Parts need Grammars

Parts form the foundation, the building blocks you need

Grammar rules specify the way the parts work in series

Grammars for Parts

Parts form the foundation, the building blocks you need

Grammar rules specify the way the parts work in series

Grammars

Grammars establish the design strategy

Subject-Verb-Object

Promoter-Cistron-Terminator

Public Grammars

GenoCAD
CAD Software for Synthetic Biology

STEP 1: PARTS STEP 2: DESIGN STEP 3: SIMULATE

Grammars Libraries My Parts My Cart (2)

Add / Import Grammar

Public Grammars

- Basic Grammar - No Simulation
- Basic Grammar with Simulation
- Gene Regulatory Networks
- User Grammars

Grammar Summary

Name: Basic Grammar - No Simulation

Description: 1, 2 or 3 cassette(s), each with a promoter, a ribosome binding site, a coding sequence and a terminator.

Icon Set: sbol_v1_0_con_set

Supports Attributes?: No

Categories: 12

Libraries: 1

Parts: 155

Rules: 4

Manage Grammar

Parent Rules

Code	Rule	Edit	Delete
Transcription			

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Follow Us:

- Basic Grammar—No Simulation for this example
- Characteristics of this grammar
- “Manage Grammar” for more details (advanced tutorial)

Obtain the Training Set

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CAD Software for Synthetic Biology

STEP 1: PARTS STEP 2: DESIGN

Grammars Libraries My Parts My Cart (2)

Add / Import Grammar

Public Grammars

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Follow Us:

figshare.com

Training_Set...Parts.genocad

click

save

<http://dx.doi.org/10.6084/m9.figshare.153827>

- www.figshare.com
- Download the GenoCAD Tutorial I “Training Set”
- Click Add/Import Grammar

Upload the Training Set

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STEP 1: PARTS STEP 2: DESIGN STEP 3: SIMULATE

Import Grammar

You are about to import the following grammar:

Grammar Name: Training Set E. Coli Grammar

Description: This is a generic grammar for gene expression cassettes

Categories: 14

Rules: 9

Icon Set: sbol_v1_0_con_set (EXISTING)

Choose an Option: ☒ USE EXISTING - Use the existing icon set. ☐ CREATE NEW - Create a new icon set and link.

Continue Import Cancel Import

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- Upload the zipped file that came from FigShare

Imported Training Set is available

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STEP 1: PARTS STEP 2: DESIGN STEP 3: SIMULATE

Manage Grammar

Name: Training Set E. Coli Grammar

Description: This is a generic grammar for gene expression cassettes

Starting Category: Start (S)

Icon Set: sbol_v1_0_con_set

Edit Export Copy Text Delete

Categories

Expand All Collapse All

- Reversible Categories
 - Expression Cassette (CAD)
 - Chaperon (CS)
 - Terminator (TER)
 - Start (S)
- Terminal Categories
 - Protein (PRO)
 - Ribosome Binding Site (RBS)
 - Gene (GEN)
 - Reverse complement open delimiter (C)
 - Reverse complement close delimiter (C)
 - Open placed delimiter (C)
 - Close placed delimiter (C)
 - Vector (VEC)
 - Orphaned Categories
 - Open chromosome delimiter (C)
 - Close chromosome delimiter (C)

Category Detail

Letter:
Description:
Genbank Qualifier:
Icon:
Delete Category Edit Category

Parent Rules

Code	Rule	Edit	Delete
There are no parent rules for the selected category.			

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Click Parts

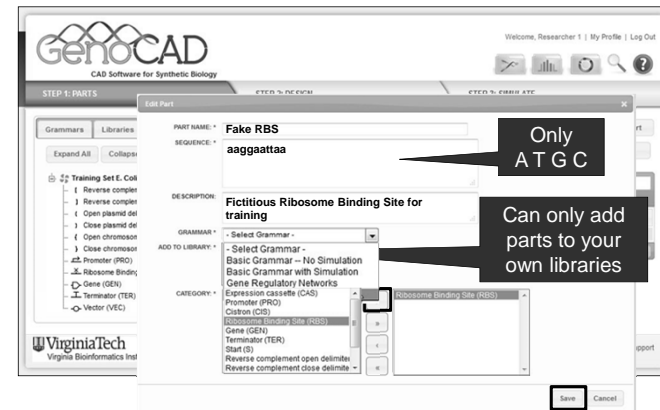
- An editable Grammar is now available
- Will be used for further work

Training Set is Integrated



- The training set grammar, library, and parts are available
- Editable, so you can change or add new
- Let's add a new part as an example

Create a Custom Part



- Good strategy: create a library for each project
- Put relevant parts in that project library

User Grammar, Library, Part Created



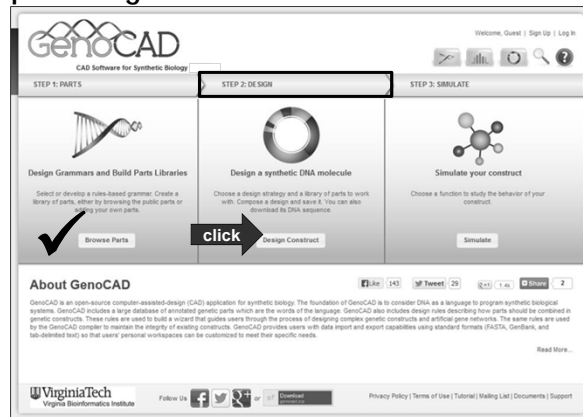
- Your custom items will be stored, now available to use
- Import parts to use and export parts for sharing or backups

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Step 2: Design Constructs



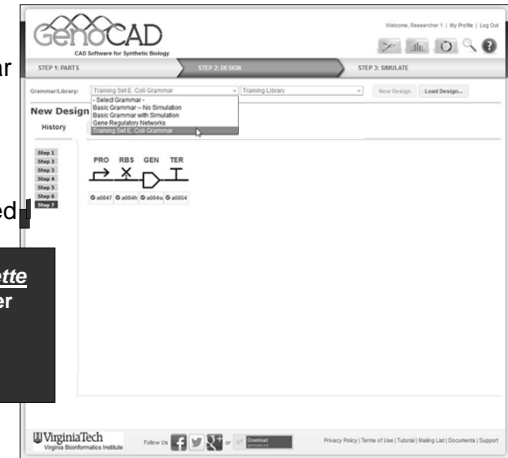
- Public and user parts, libraries, grammars in place
- Use them to create a construct with “Design” options

Design Constructs

- Choose grammar
- Choose library
- Begin to design
- Choices are listed

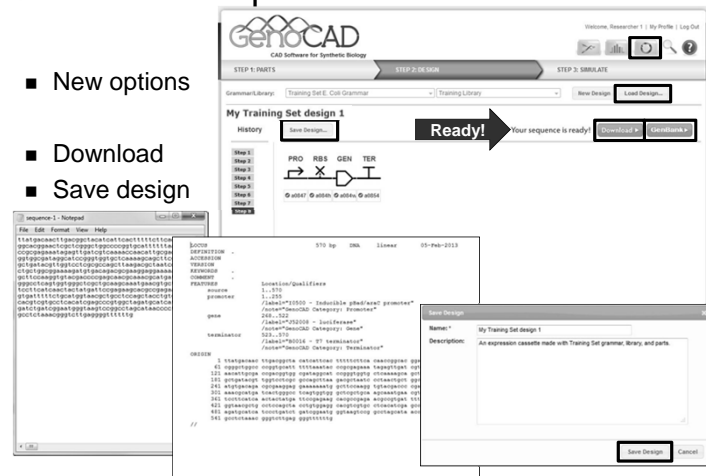
Build a simple cassette

- Inducible promoter
- RBS A
- Luciferase
- T7 terminator

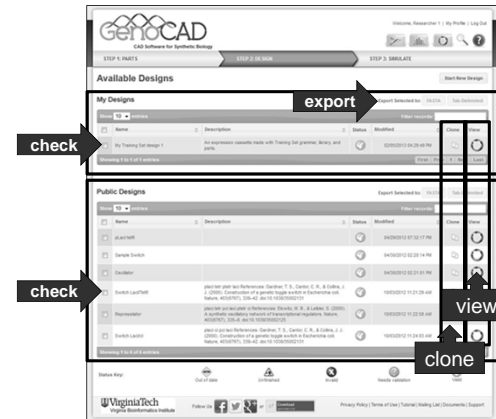


Construct is Complete

- New options
- Download
- Save design

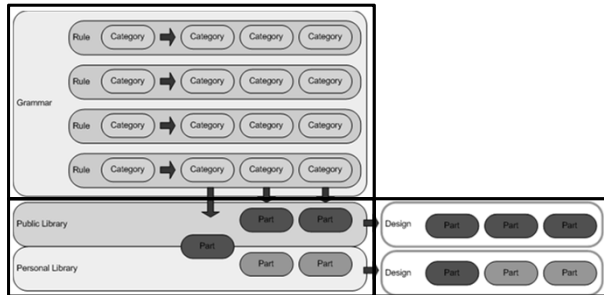


Browse for Constructs



- “Load Design” or “Available Designs” folder to see the list
- Yours + public designs are shown

Data Model



- Parts and Libraries
- Grammar and Rules
- Design your constructs

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Step 3: Simulate

- Step 3: Simulate

Constructs Ready for Simulation

- If you generate with attributes for simulation, they will be listed
- Public examples

Repressilator Example

- Design of the construct
- 3 cassettes in a network
- Parts + Grammar + Design carries key details

Simulation Sample

- Duration and interval are set
- Run Simulation to obtain the display

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GenoCAD Introduction Summary

- GenoCAD is a toolbox for synthetic biology
- Parts, grammars, designs, and simulations



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