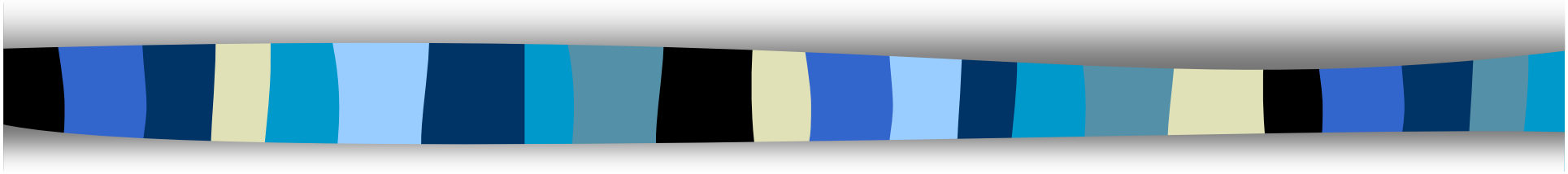
Using Molecular Biology as a Metaphor for Adaptive Evolutionary Information Systems



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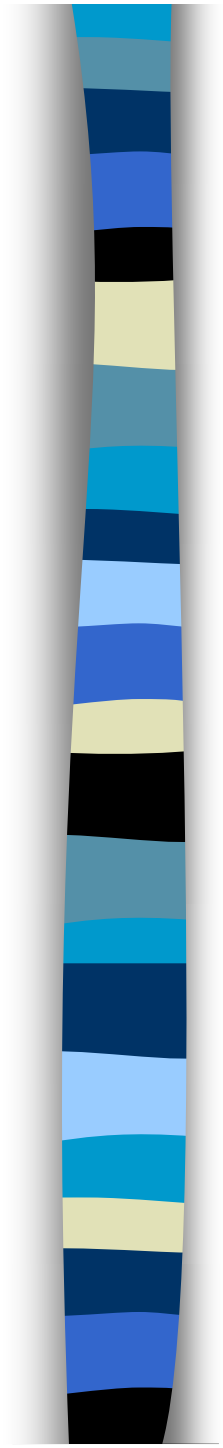


Overview

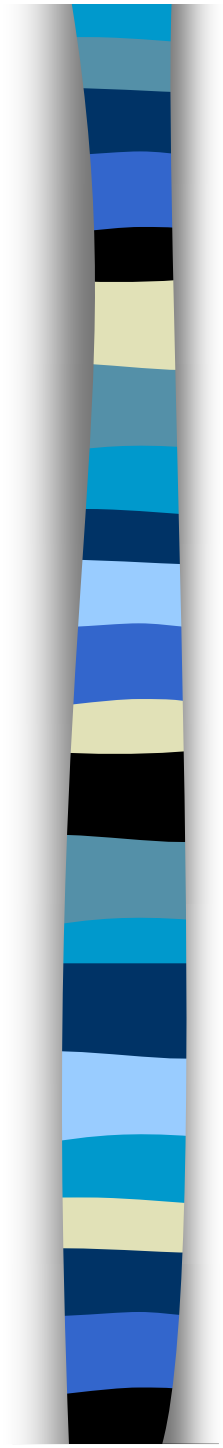
Properties of an Adaptive Evolutionary Information System

Why Cellular Mechanism may provide a good example mechanism.

A Specification for an Evolutionary Information System

- Structuring the Specification
- Component Structure
- Exons and Introns
- Homeotic Components
- Evolving the System
- Domain Specificity
- Information Receptors

Conclusions



Properties of Biological Systems

Strongly conserved molecular mechanisms

Simple building blocks

Complex and emerging behaviour and structure

Evolution by selection

Hierarchical structures

Properties of an adaptive information system

Ability to identify and respond to stimuli

Ability to identify when to change and when not to

Mechanism for changing and replacing operational components.

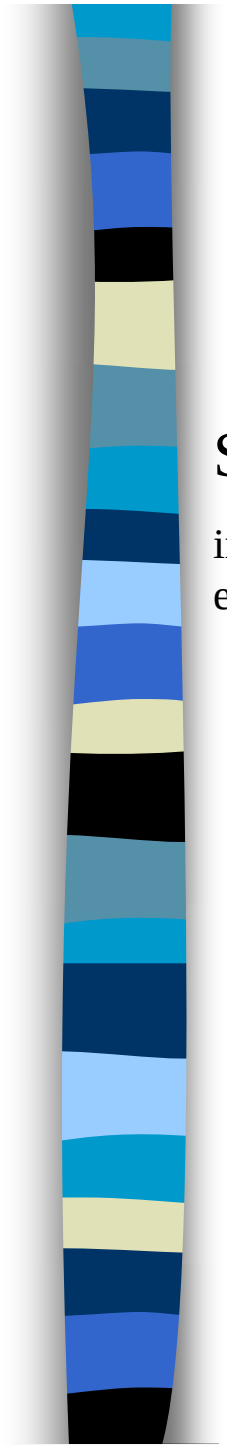
Ability to identify boundaries.

Coherent and standardised messaging system.

Comprehensive set of building blocks

Selection mechanism

Set of support tools for triggering and controlling development



Basic Model

Stimulus

in the environment

→

Change in Specification

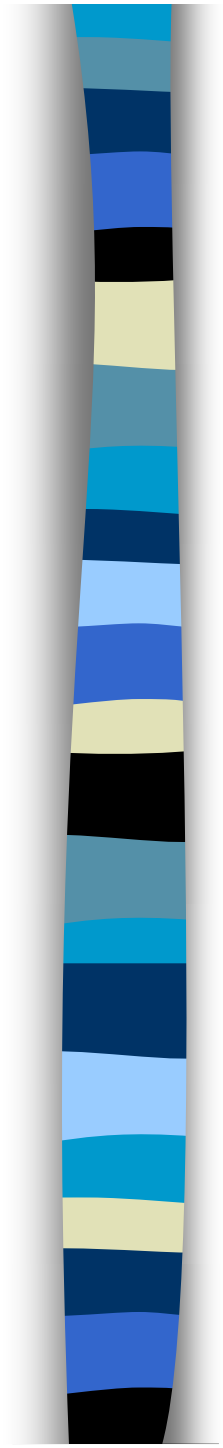
→

Expression of that change in the system

Detection

Definition

Description



Business environment changes

System detects change

Systems defines response

Response coded in specification

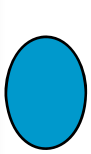
Specification expressed in information systems environment as active component

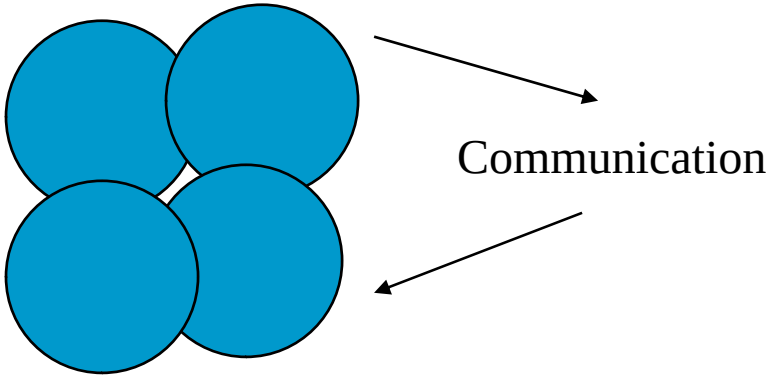
Biological organisms as aggregates of cells

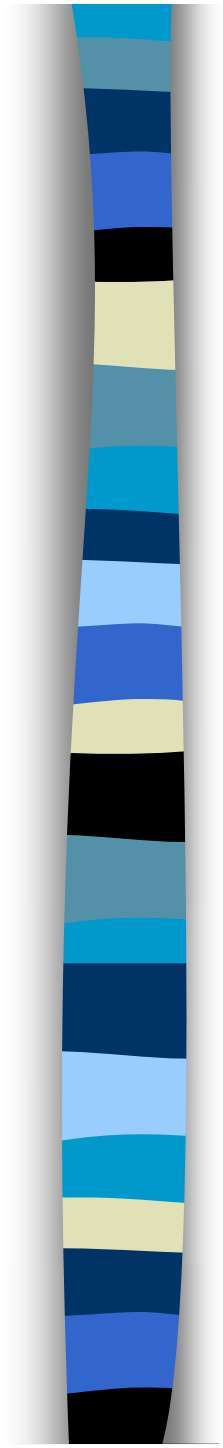
Cells

Aggregation

Functional Domain



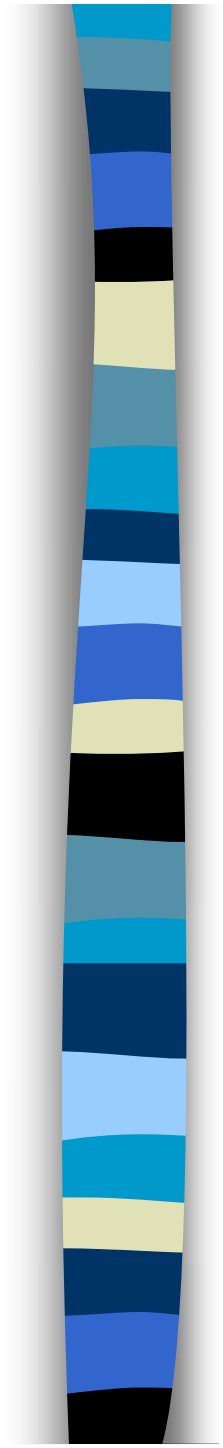




All possible domains stored in each cell

Cell’s function determined by selective expression of genome;

Maintained by communication



transcription

translation

DNA → mRNA → Proteins

Polymerases

tRNA,
rRNA.

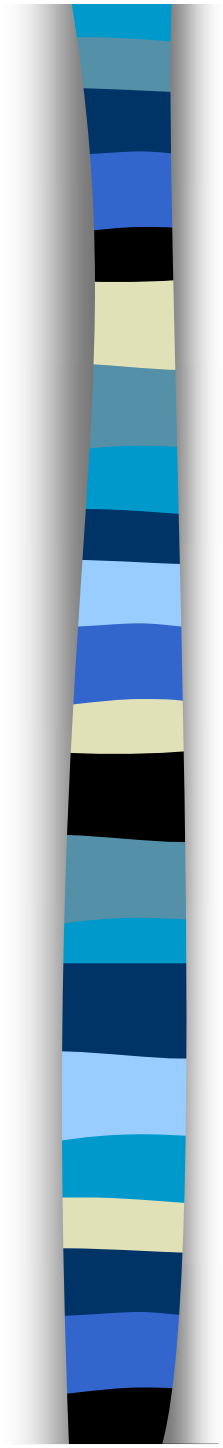
Bases
(GTAC)

↓

Codons

↓

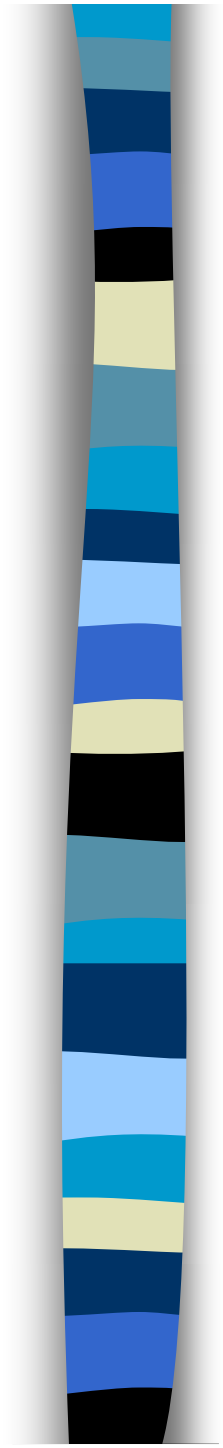
Amino
acids



Replication

Mutation (at ‘hotspots’)

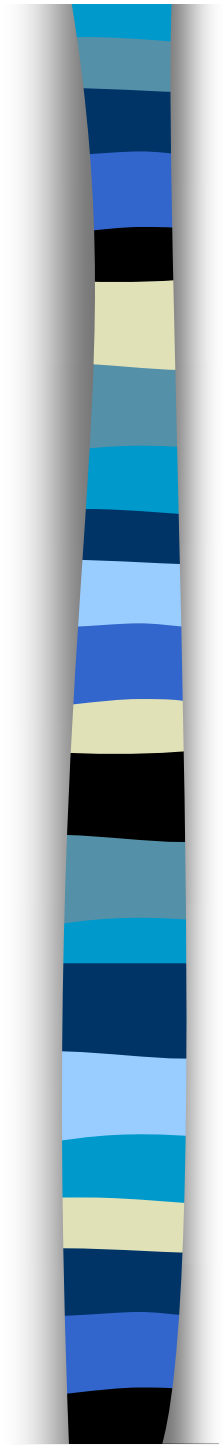
Recombination



Analogy 1

Cell → Component

Functional Domain → Aggregation of Components



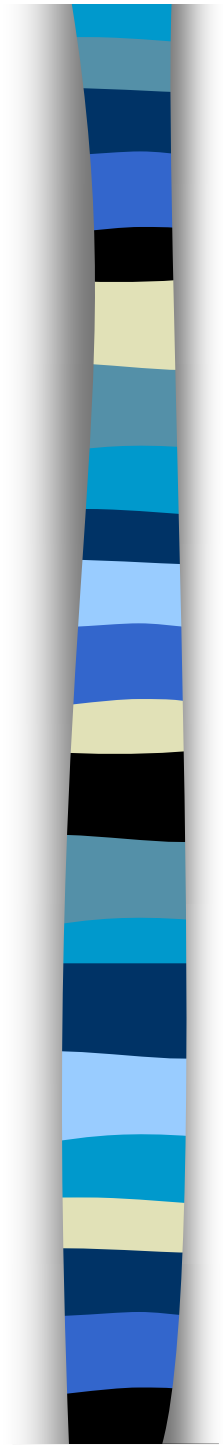
Analogy 2

Components defined in specification

Specification ‘transcribed’ into active components

Protein ⟶ Component

- Control-oriented components
- Client-oriented components

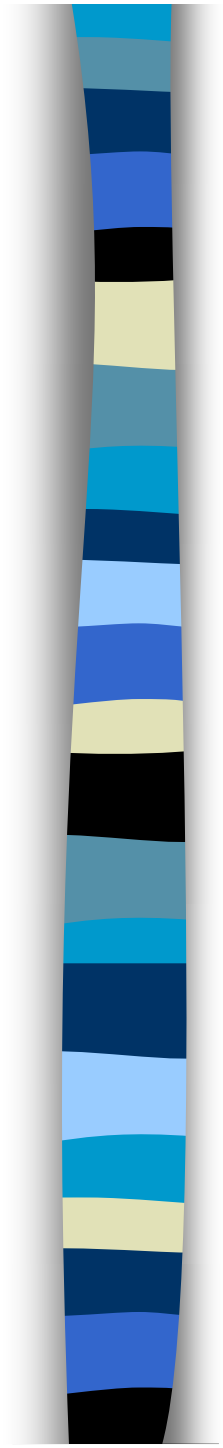


Conservation of the Specification

Repair and Rework

Error Checking.

Component Structure.



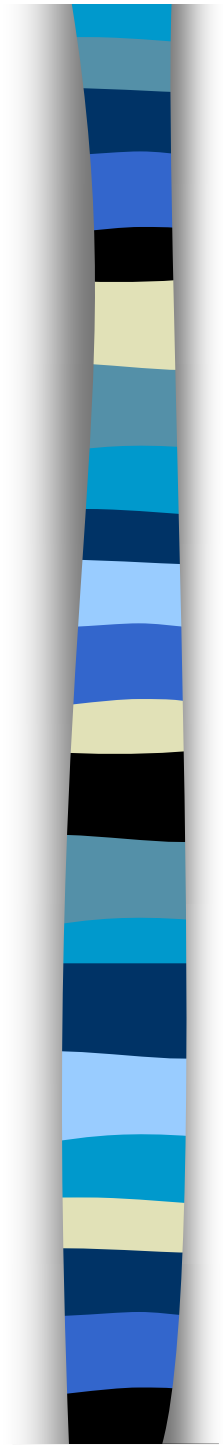
Genome Structure

Sixty-one codons

20 amino acids

Standard Control Structures

- Promotors
- Inhibitors



Genome Structure

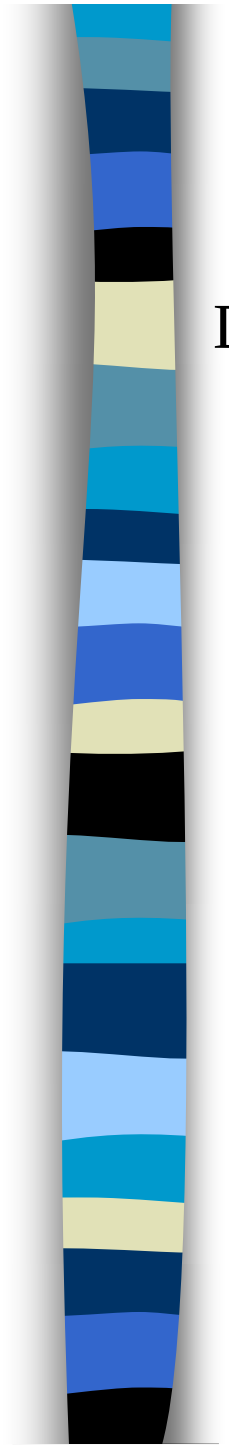
Human genome - 25-35K genes

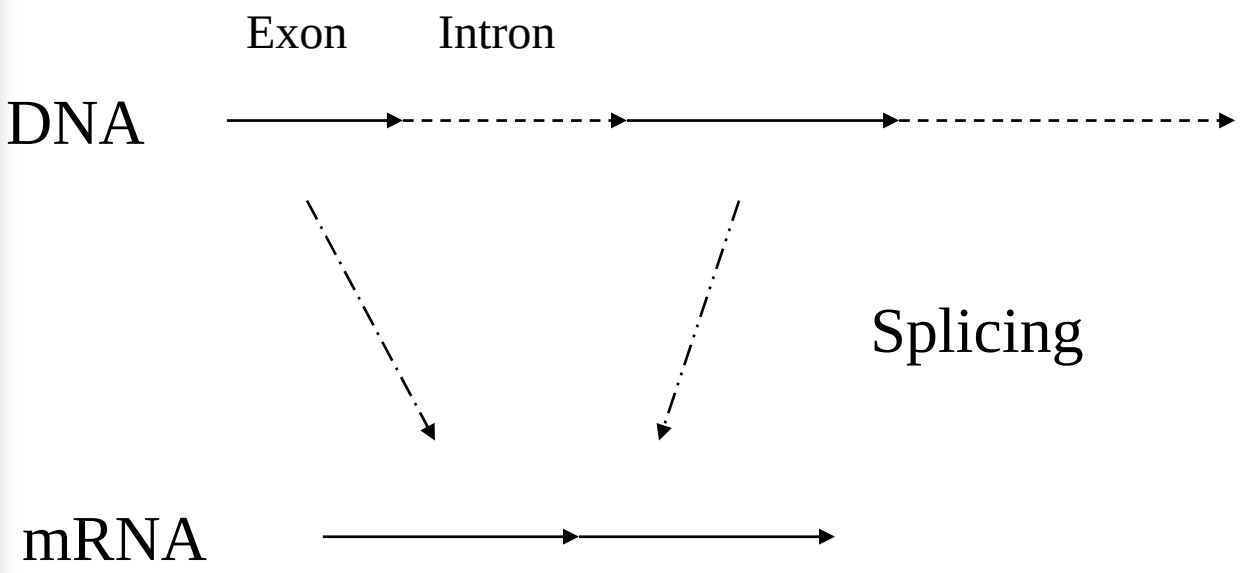
33k million bases

Highly repetitive

Moderately repetitive

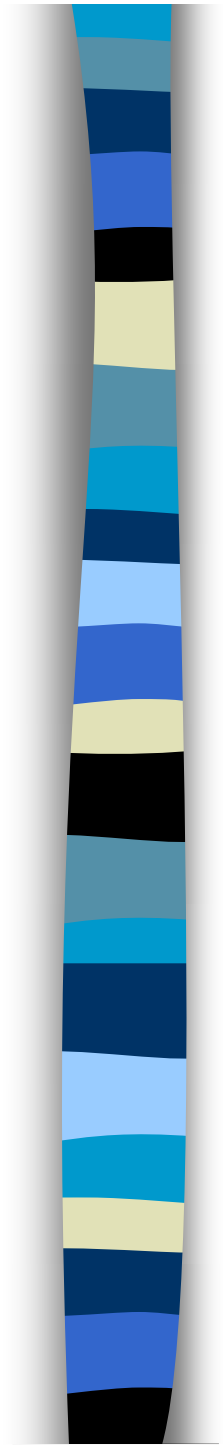
Non-repetitive





Multiple splicing

Mobile introns



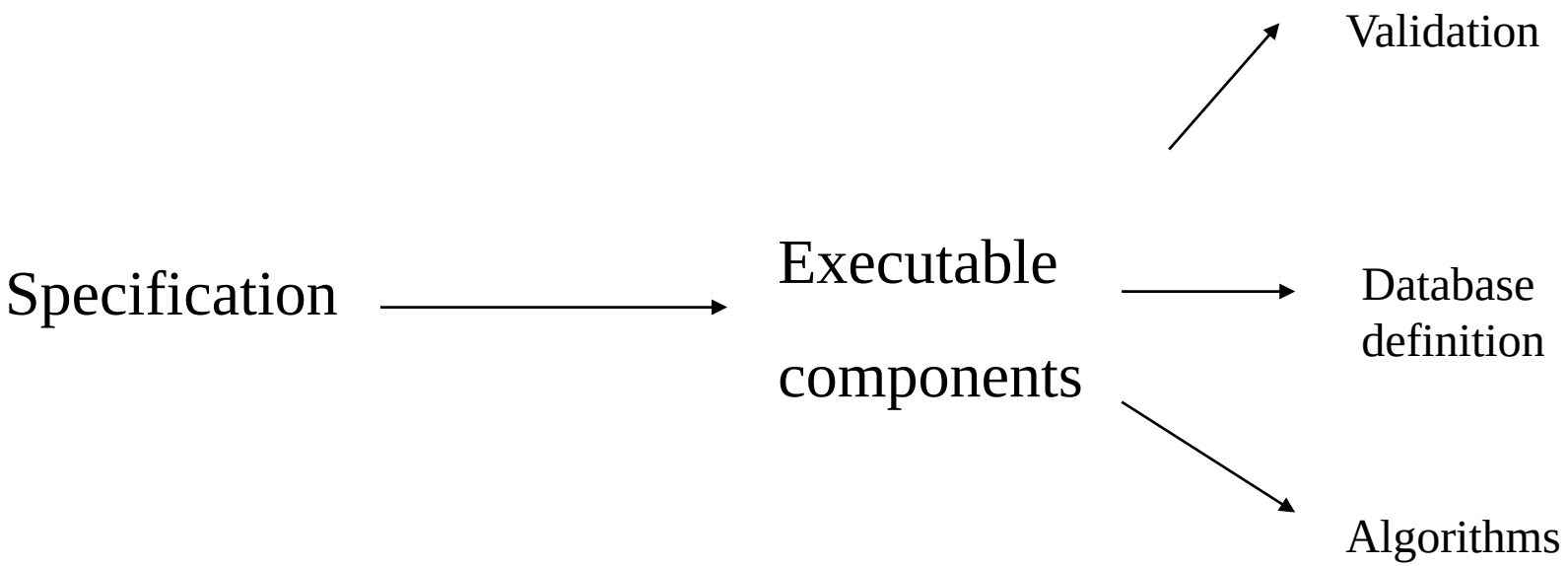
mRNA Populations

Egg protein 100,000 copies

Other major proteins (8) 4000 copies

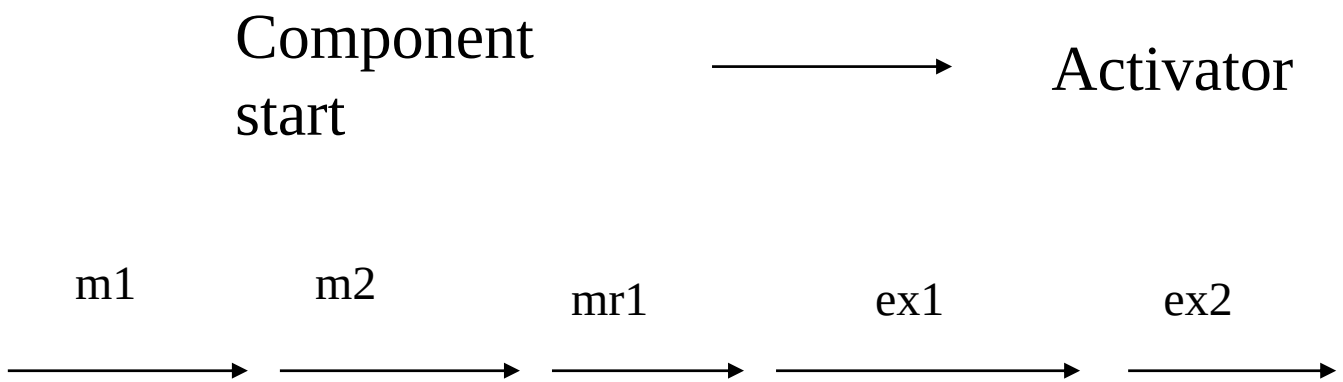
Minor proteins (13,000) 5 copies.

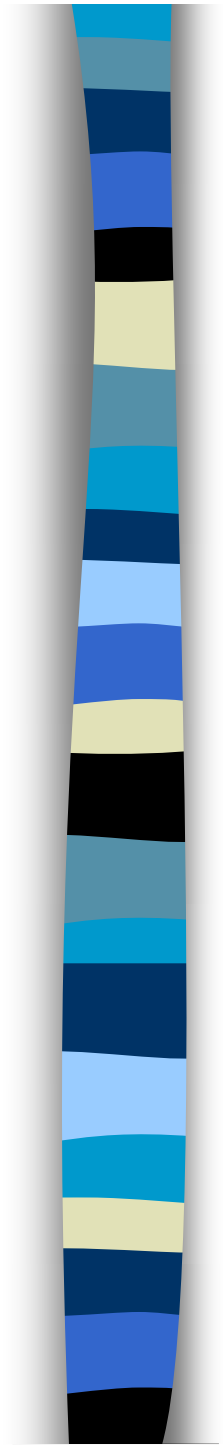
Adaptive EIS Structure



All necessary components for all domains with an organisation

Component structures



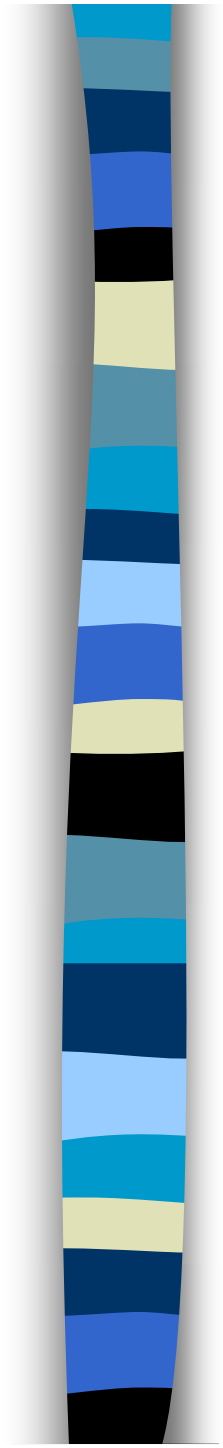


Messages

Glue for assembling components into systems

Can be copied from component to another

Can be components themselves.



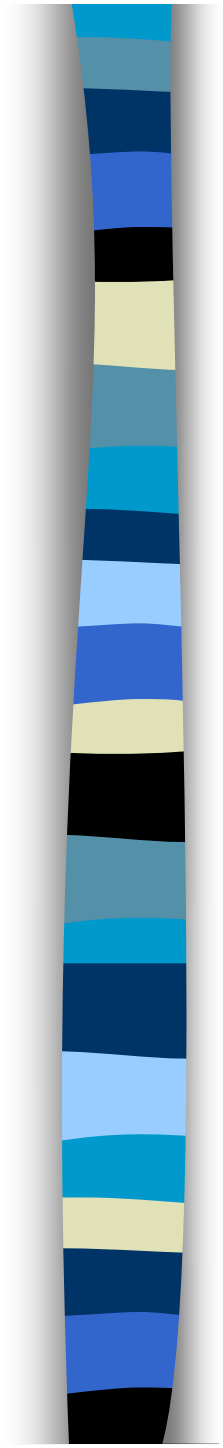
Exons may contain common units of processing.

Components inactivated by switching off starters.

New components built by copying old one, inserting new exons and messages to alter functionality.

Specification contains library of processing exons.

Variation possible in same exon in different components.



Homeotic Components

Homeotic Genes

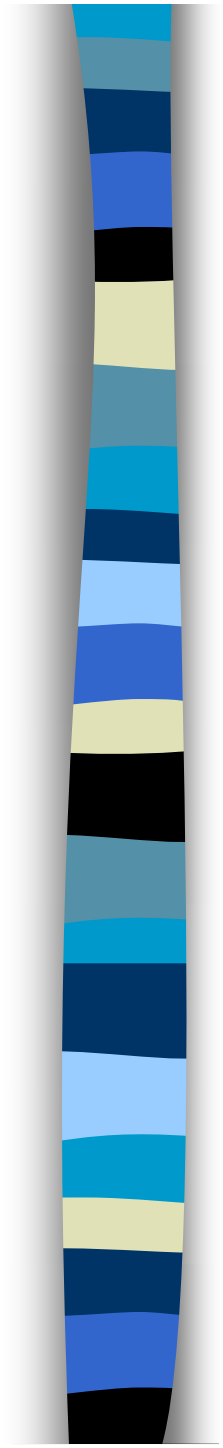
Control identity of body segments / functions.

Binding proteins control transcription of other genes.

Cascades of homeotic genes.

Confer memory of type on cell.

Highly conserved.



Homeotic Components

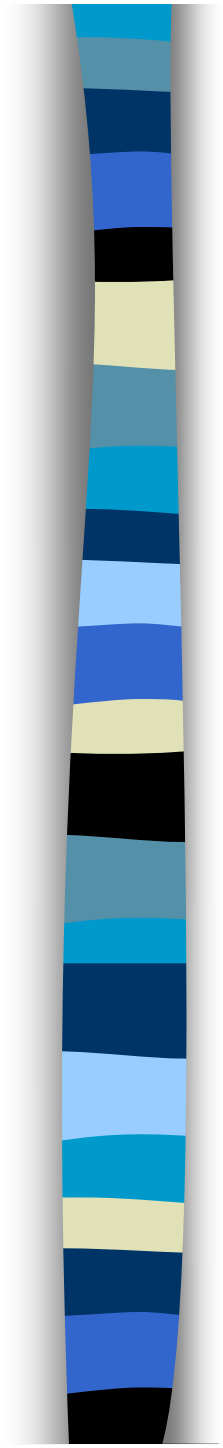
Specification level - control what components are selected from the specification.

Operational level - provide messages which promote aggregation and control temporal component activity

Regular development of information system domain.

May respond to environmental signals.

Homeotic components may interact to determine patterns-in-the-large



Homeotic components may act on the specification

Parts of the specification are executed in order to make decisions about the transcription of other parts of the specification.

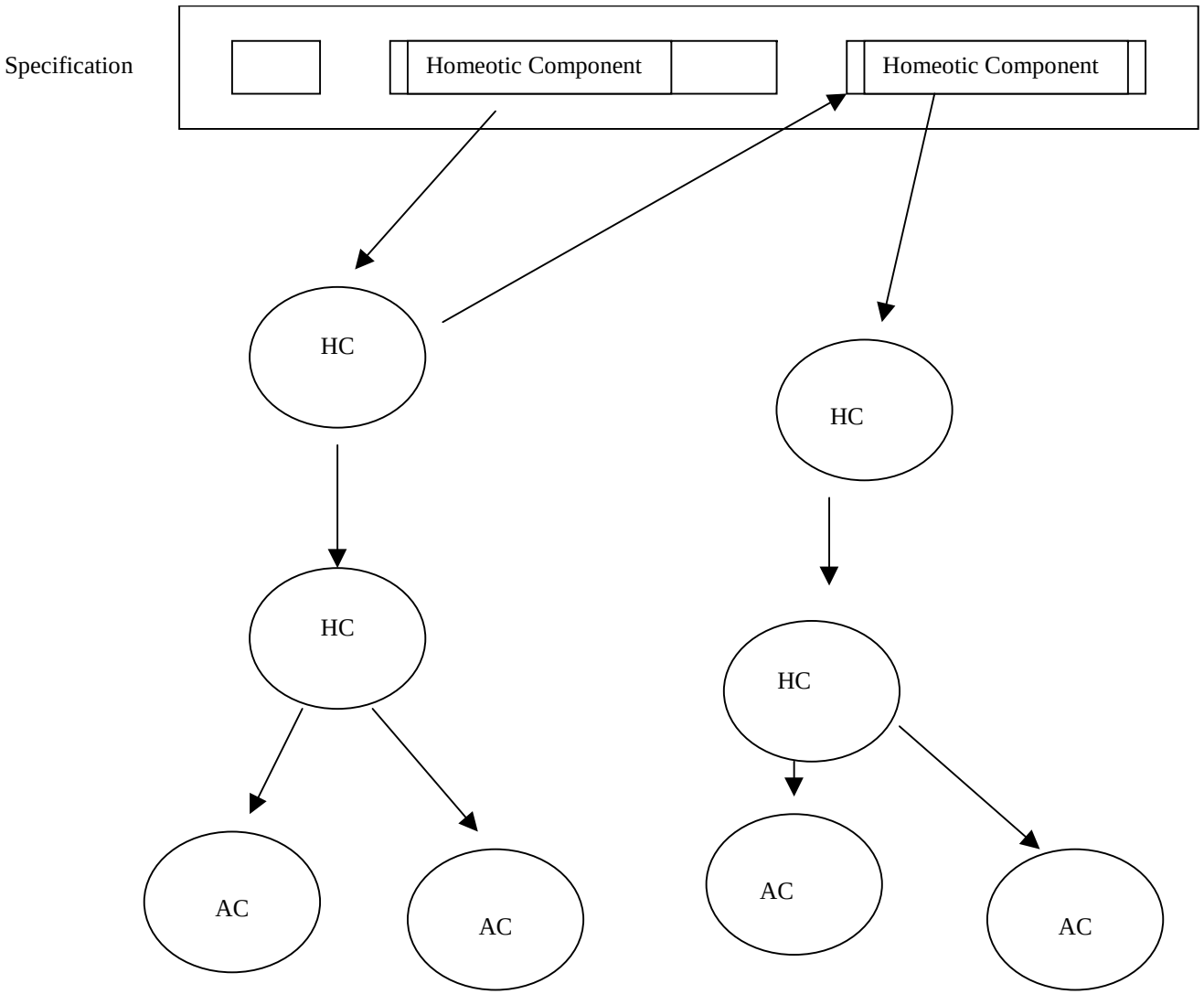
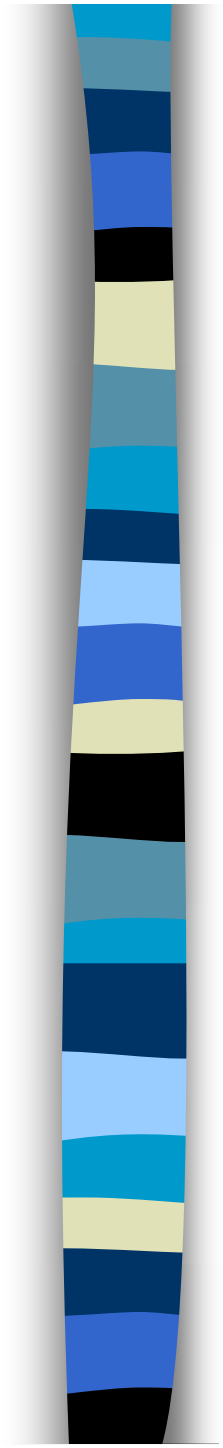


Figure 1. Homeotic components (HC) control adaptive evolutionary information system structure by promoting the reading of other homeotic components from the specification and messaging other homeotic components and application components (AC) within the operational system.

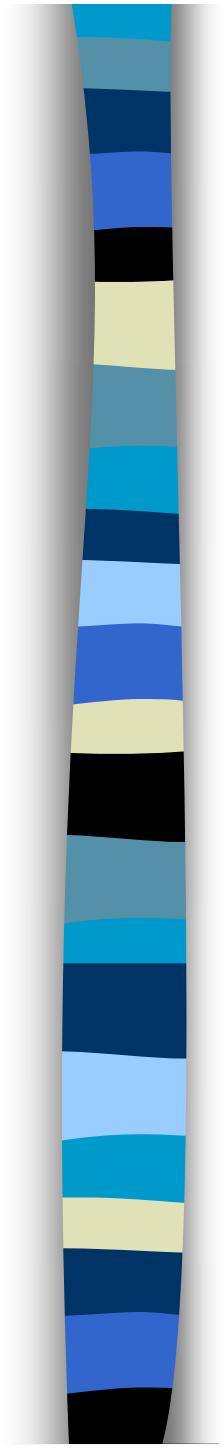


Adaptive Evolutionary Information Systems

Hierarchy of patterns

- Component Aggregation
- Exon aggregation
- Sub-unit aggregation

Which are dynamic, recombinable and fluid



Evolving an Adaptive EIS

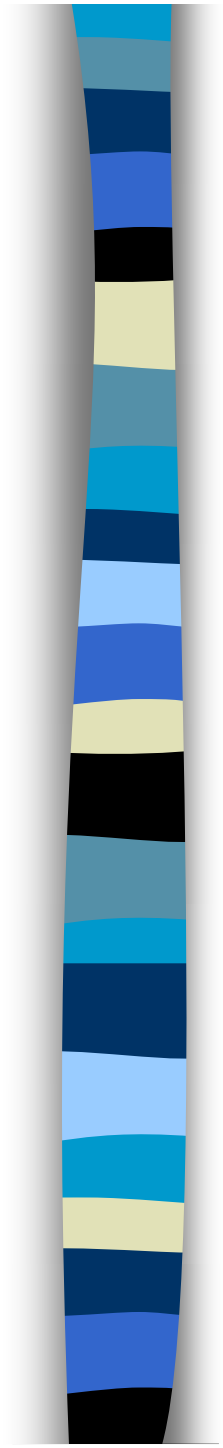
Adding new messages

Removing messages from components

Switching off components

Duplicating and mutation components

Exogenous addition of components



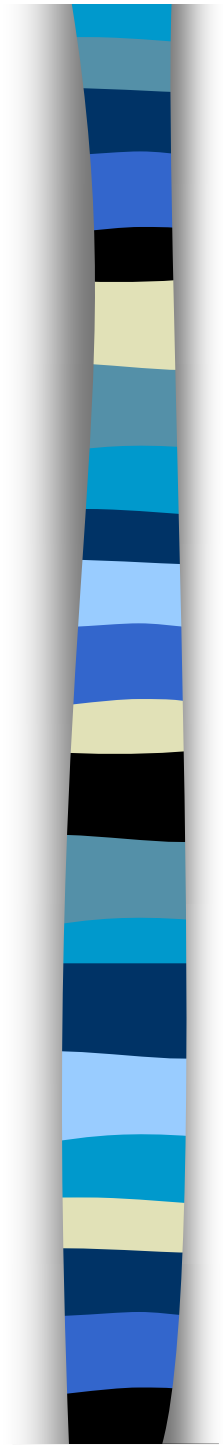
Switching between evolving and non-evolving

Evolve mode

Operational mode

Evolve

- React to changes
- Alter components
- Create new generation of systems

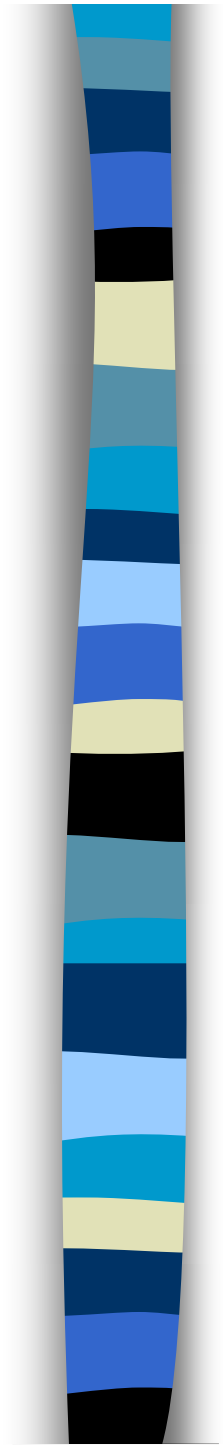


Lamarckian

Environmental change

Transmission by information receptors

Specification change



Receptors

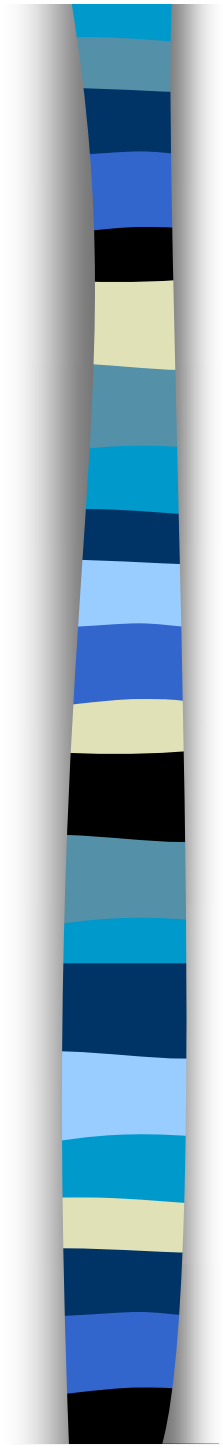
Located in cell membranes;

Bind reversibly;

Receptor has increased affinity for DNA;

Standard communication system;

Receptor specific to ligands.



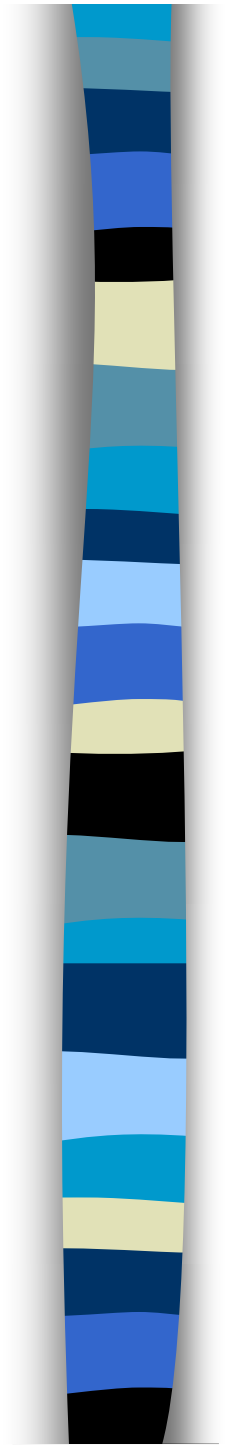
Information Receptors

Are themselves components;

Present at the interface - or exposed in evolve mode;

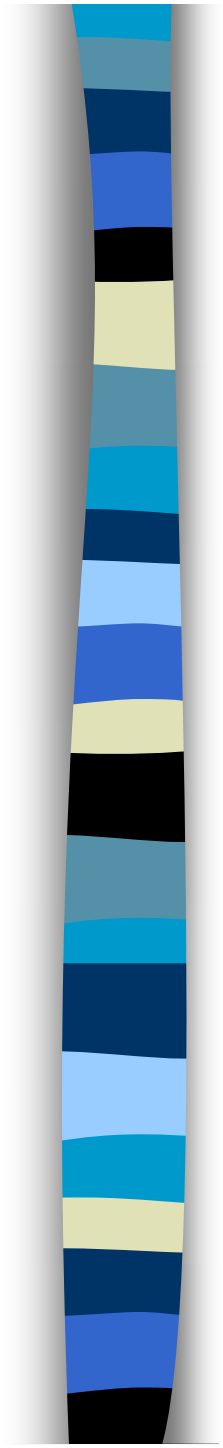
Pick up signals;

React with specification to change other components.



The Implementation Process

Take the existing commercial system and break it down to identify all exons and messages.
Design transcription and translation mechanisms
Design control mechanisms
Define homeotic components
Create a classification of environmental change relevant to the system
Design a series of information receptors
Define the transmission mechanisms for those information receptors and defining how they interact with adaptive EIS components and how they change the specification.
Create assemblages of components and define homeotic component control pathways.



Further Investigation

Nature and classification of changes in commercial systems.

Structure and mechanism for receptor / ligand interaction.