Signal Transduction

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What is **Signal Transduction**?

It's the process of converting signals into responses

i.e., receiving, interpreting, processing, amplifying and responding to information

Why is Signal Transduction required?

Forms of secreted molecules-mediated signaling



Differences:

Distance: Paracrine signal travels short distances (few mm). A neurotransmitter travels 10-20nm. An endocrine signal (hormones) travel (in the circulation system) upto the entire length of the body. Thus, hormones are systemic effectors.

Timing: Neural signaling is brief: transmits and effects in less than a second. Endocrine signaling is longer: signals take more time to reach their targets, target cells take more time to respond, and signals are more stable.

Components of Signal Transduction





Wnt signaling pathway has an essential role in growth and development of all most all organs and tissues of our body...



EGFR Pathway



Major Signal Transduction Pathways



Evolution and Expansion of Intracellular Signaling

		Phylum	Species	Kinases	CTKs	RTKs	EGFRs	MAPKs	Genome
Genom	e duplication >	Vertebrates	Homo sapiens	518	33	58	4	10	22980
	Deuterostomes	Urochordates	Ciona intestinalis	316	33	16	2 ⁺⁺	5	15852
Bilaterians Metazoans		Echinoderms	Strongylocentrotus purpuratus	353	35	19	1	5	23300
	Protostomes Ecdysozoans	Arthropods	Drosophila melanogaster	251	15	17	1	4	13808
		Nematodes	Caenorhabditis elegans	454	22 ⁺	12	1	4	19484
		- Cnidarians - Ctenophorans - Poriferans							
		Choanoflagellates	Monosiga brevicollis	ND	ND	>7	1	≥3	9196
		- Fungi - Plants							
		- Other eukaryotes	Dictyosteleum	285	0	0	0	2	12500

Mitogen Activated Protein Kinase (MAPK) pathway : A typical example





How is pleiotropy in biological function achieved from a relatively simple biochemical pathway? (inherent to this is also the question of specificity) Amplitude and duration of the signal flux

Combinatorial integration of network crosstalk

Versatility of component function

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Versatility of component function





Signal form rain results in umbrella opening



Model of signal transduction:monkey puzzle

Is more better than less?

Why do MAPKs have a 3 tiered structure?

Does dual phosphorylation requirement of MAPKs for activation have an advantage?

Feedback loops



Scaffold proteins: localization/specificity



The question of Integration: can Neural Networks help?



Neural networks can be trained to recognize specific input patterns and generate corresponding specific output patterns

Thickness of arrows indicate connection weight

A neural network trained by evolution!

Characteristics of a Robust system

-Bow-tie structure: core circuitary link input and output and is a point of fragility

-Modularity: divided into partially autonomous subsystems allowing diversification and damage containment

-Functional redundancy

-Systems control:bidirectional coupling of input and output via +/- feedback loops

-Pathway switching: extensive branching allows dynamic switching of signals to alternate routes

-Tolerance: ability to accumulate aberrations without significantly altering output

Large interactive networks (incl. Neural Networks) display Robustness

ie, can maintain function despite external and internal perturbations

Robustness is essential for:

Appropriate communication

Generating appropriate response

Correct development

Cellular malfunction

