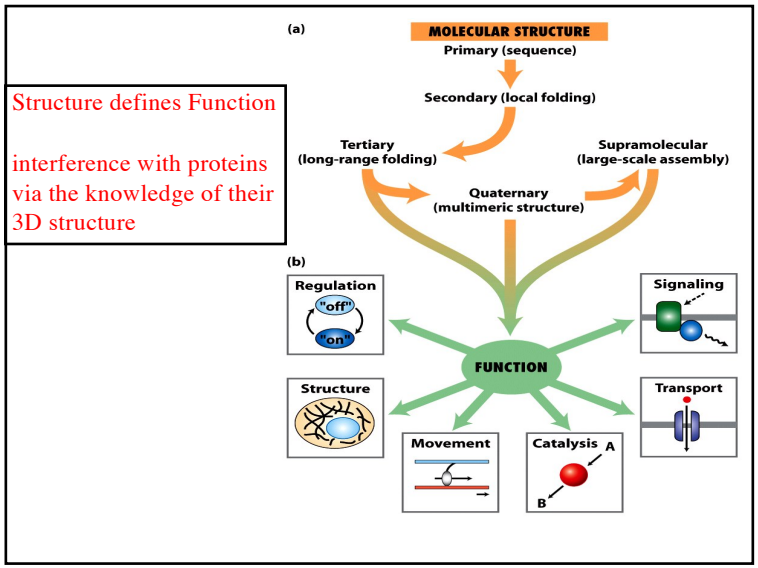
Molecular and Cellular Biology

4. Proteins: Structure and Function

Prof. Dr. Klaus Heese

Structure defines Function

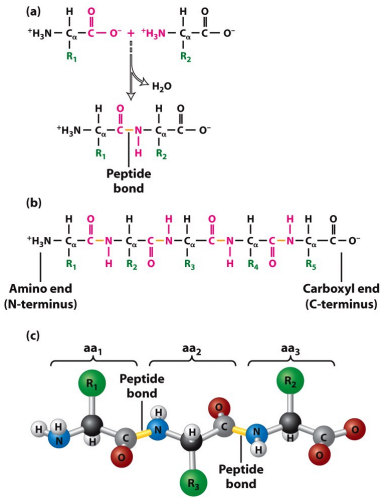
interference with proteins via the knowledge of their 3D structure

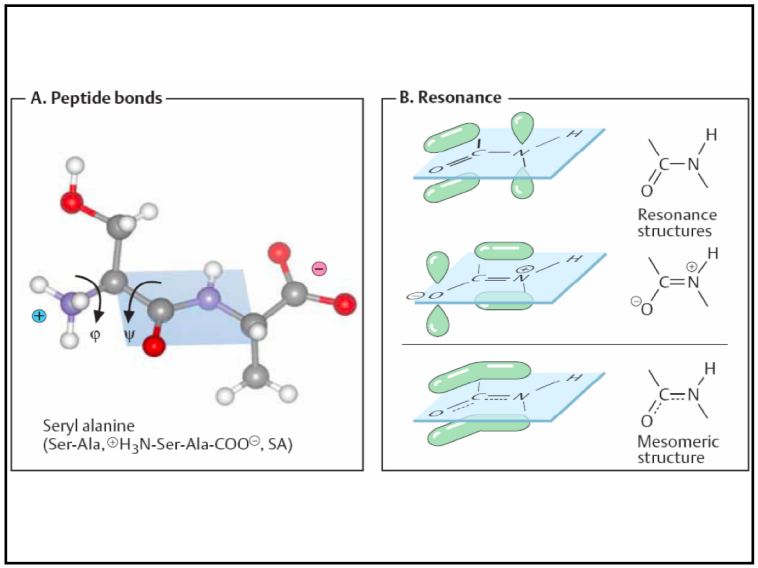


Amino acids

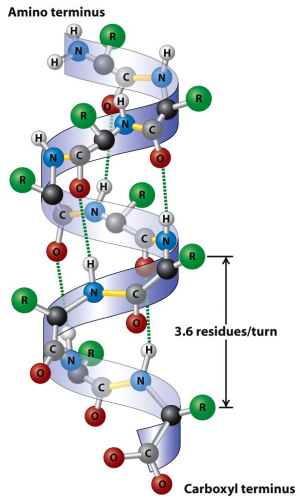
Peptides

Proteins

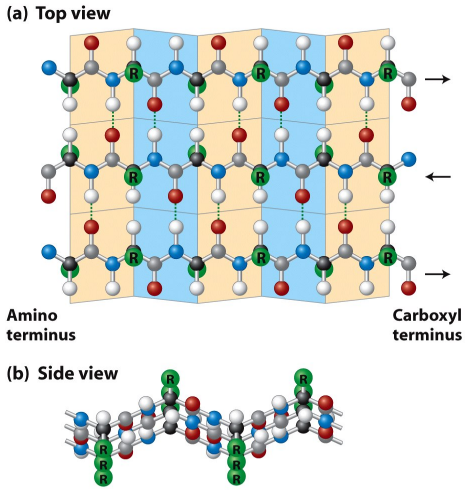




Helix



Sheet



Protein conformation (3D structure) change induces protein function change

http://www.youtube.com/watch?v=YAva4g3Pk6k

http://www.youtube.com/watch?v=4TGDPotbJV4

http://www.youtube.com/watch?v=CNWaMEW9QZ8&feature=watch_response

Moving vesicle

http://www.youtube.com/watch?v=y-uuk4Pr2i8

http://www.youtube.com/watch?v=B_zD3NxSsD8&feature=fvwp

Kinesin Walking (by Atomic Force Microscopy)

http://www.se.kanazawa-u.ac.jp/bioafm_center/movies/Walking_myosinV-2.gif

protein action

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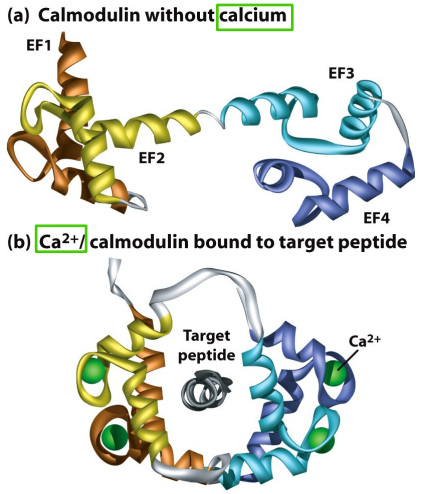
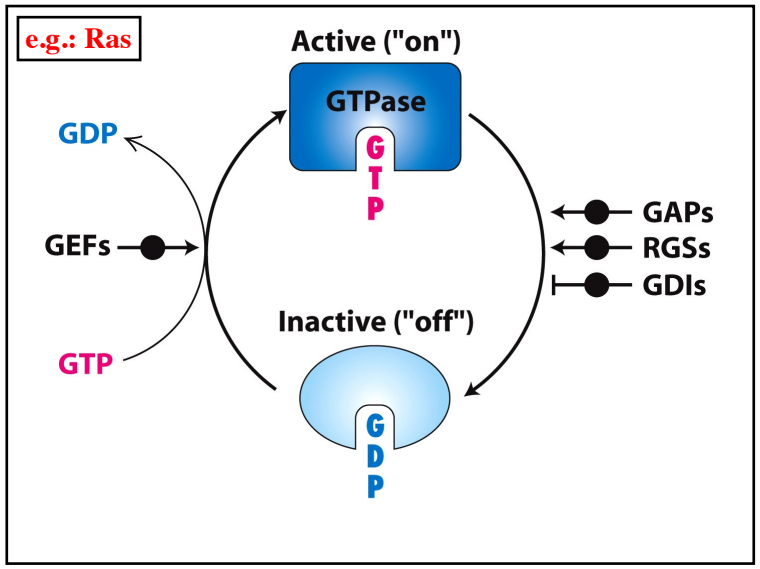
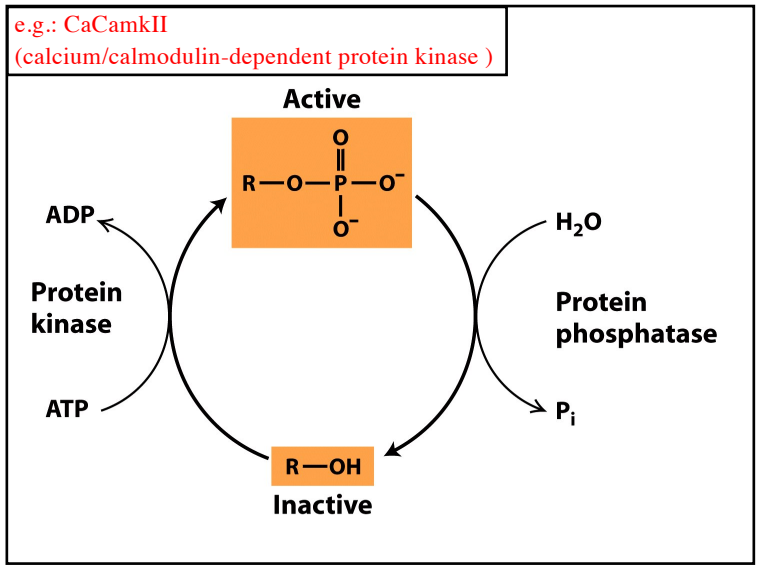
on/off







Protein Folding & Diseases

Box 1 | **Prion nomenclature**

α-PrP
The α-helix-rich form of PrP, represented by PrP^{C}.

β-PrP
The β-sheet-rich forms of PrP can be generated from the oxidized and from the reduced form of PrP by exposure to various chemical treatments. They can form fibrillary structures, particularly when amino-terminally truncated.

PrP^{C}
The physiologically occurring, mainly GPI-linked form of PrP, or prion protein, that can be glycosylated on one or both of two asparagine residues with a variety of glycans. As shown by NMR and X-ray crystallography, it is rich in α-helical structure and contains only a little β-sheet structure.

PrP^{iso}
A designation I propose, for any stable form of PrP that differs from PrP^{C} only by virtue of its conformation but not primary structure. Such differences may currently be detected by a variety of methods, such as reactivity to certain monoclonal antibodies, conformation-dependent immunoassay, susceptibility to proteinases, including the location of cleavage site(s), and optical measurements such as infra-red or circular dichroism. PrP^{iso} comprises, among others, PrP-res, PrP^{Sc} or $sPrP^{Sc}$, as defined below.

PrP^{Sc}
An isoform of PrP^{C} that is almost invariably detected in TSE-infected tissues and cells. It comprises a carboxy-proximal segment of about 140 residues that is resistant to defined conditions of PK treatment. The term PrP^{Sc} is used by some interchangeably with prion, a usage that should be avoided. PrP^{Sc} designates a structure, prion is a functional concept. The implication that a particular form of PrP is the only essential constituent of the prion remains to be proven.

PrP27-30
The PrP fragment remaining after controlled PK digestion of PrP^{Sc}.

PrP-res
Alternative designation for PrP^{Sc}, that has been proposed to generalize the term for all types of TSEs and not only scrapie.

PrP-sen
The designation for PrP^{C} and forms of PrP that are equally susceptible to PK digestion.

PrP^{*}
A hypothetical isoform of PrP that is the essential component of the TSE agent or prion.

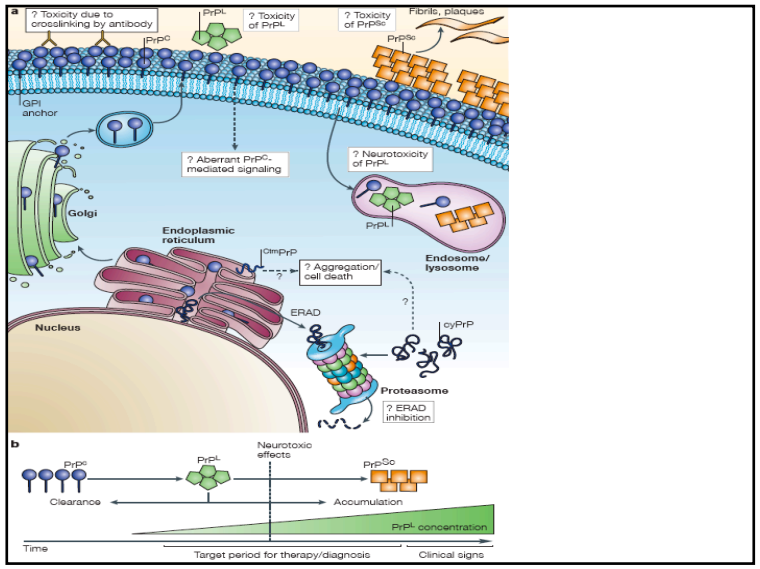
Prnp
The gene encoding PrP.

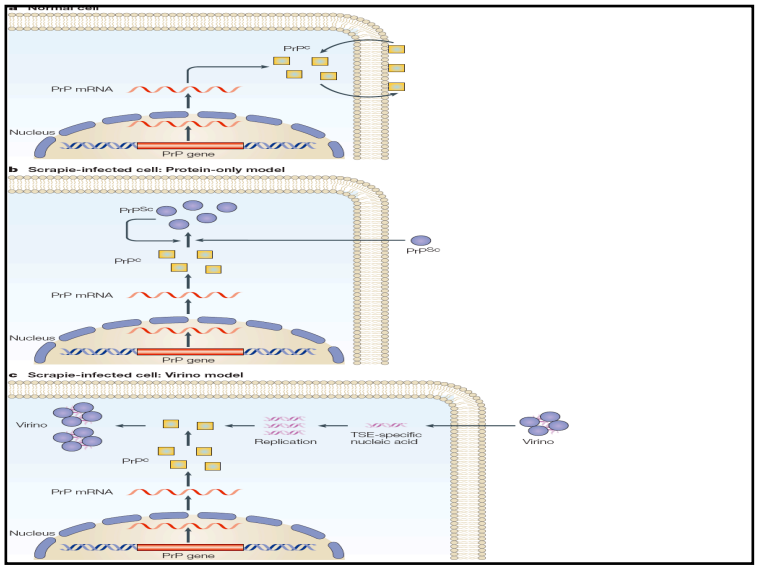
$Prnp^{0/0}$
Genotype in which both copies of the PrP gene are inactivated or ablated.

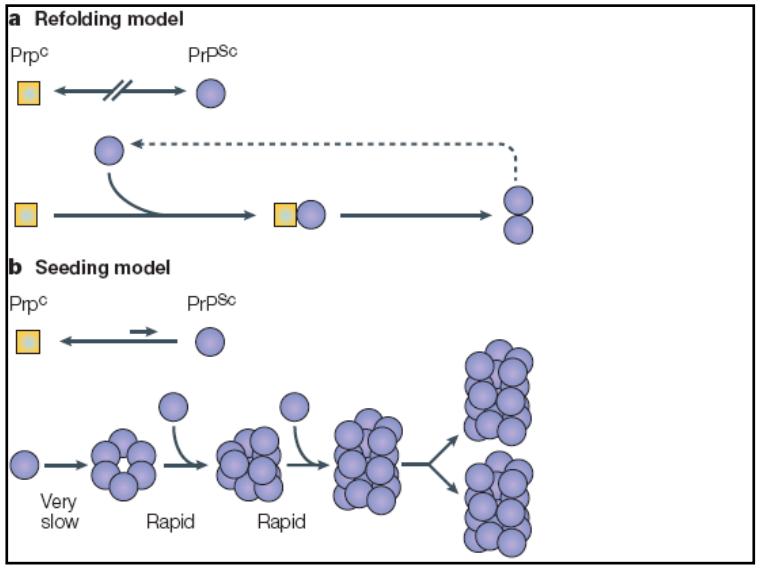
rPrP
Denotes recombinant PrP. When produced in *Escherichia coli* it lacks the GPI anchor and the glycan residues.

$sPrP^{Sc}$
A term used by Prusiner to designate a protease-sensitive isoform of PrP that is detected in prion-infected tissue. This terminology is contradictory because PrP^{Sc} was originally defined as a protease-resistant entity.

Prion:
The transmissible agent that is responsible for prion diseases, which, according to the 'protein-only' hypothesis, lacks an agent-specific nucleic acid genome and is composed principally or entirely of a conformational isomer of cellular prion protein. A term that was originally coined by Prusiner from 'proteinaceous infectious particle'. Highly expressed in brain, in neurons and glia cells, probably anti-oxidative stress function, cell adhesion, stem cell character.







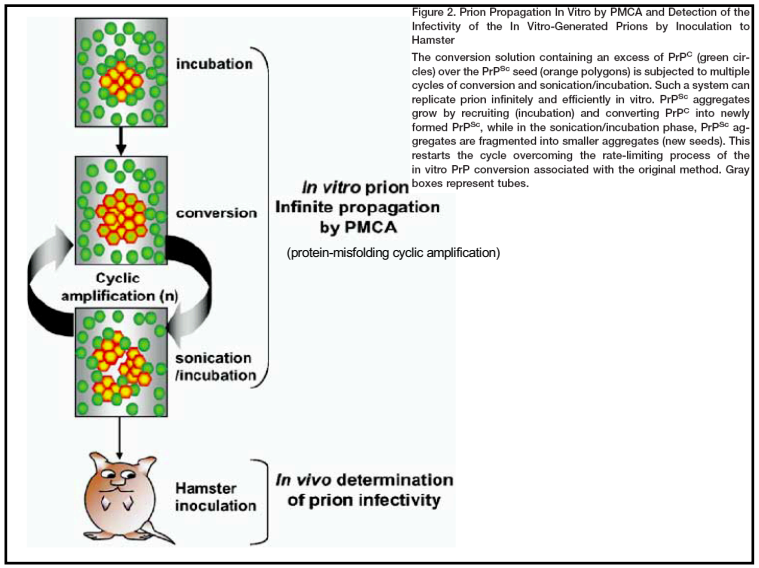
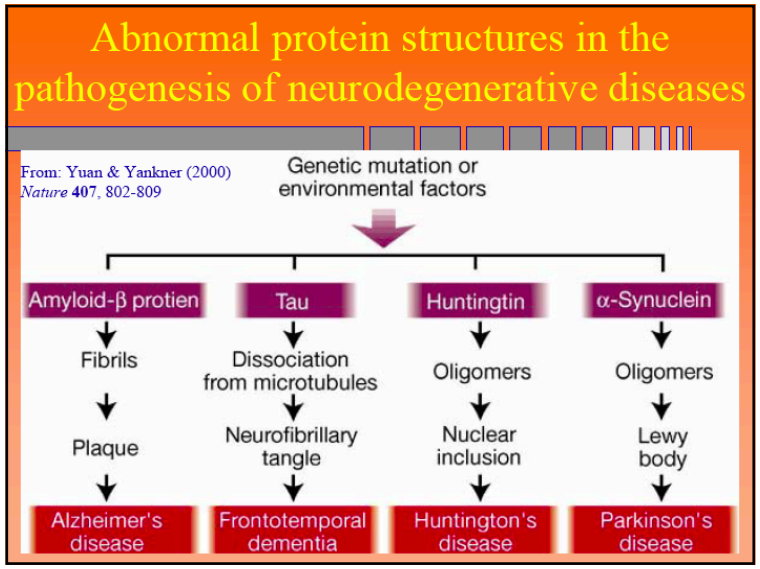
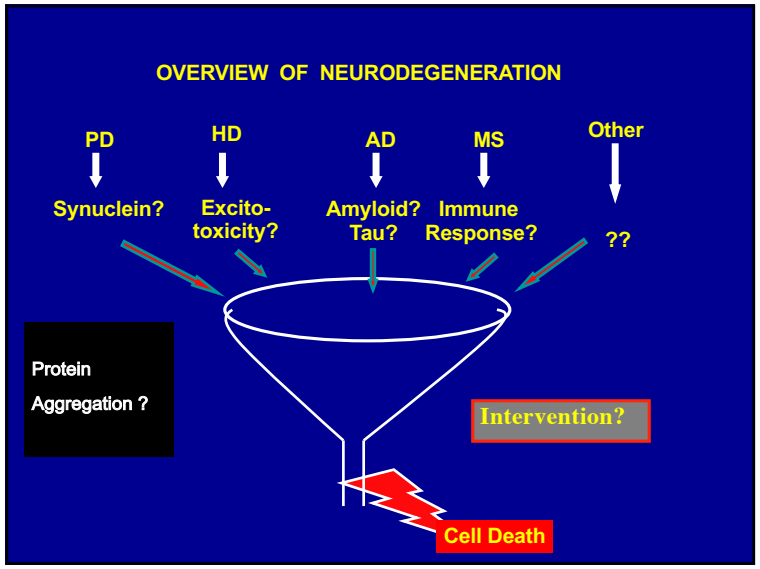
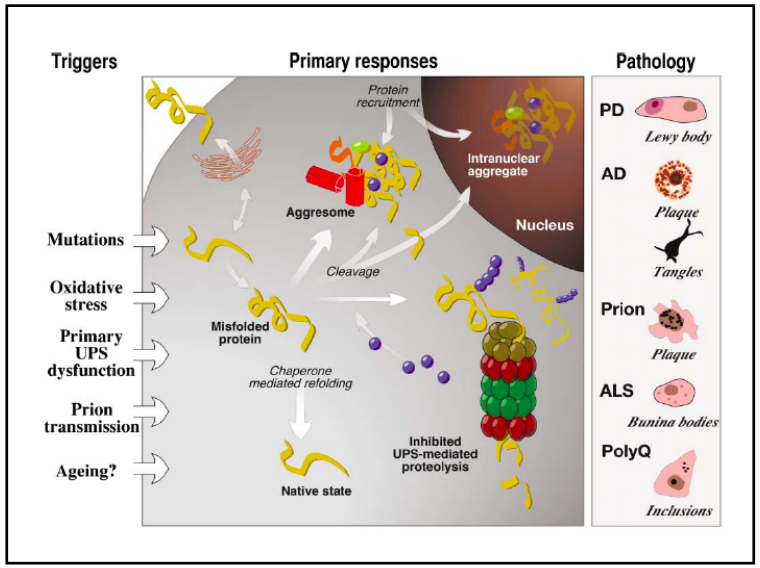


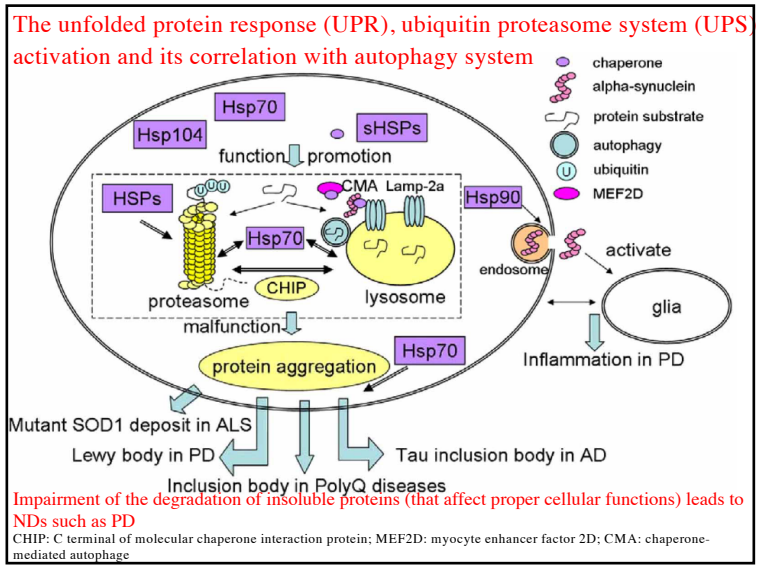
Figure 2. Prion Propagation In Vitro by PMCA and Detection of the Infectivity of the In Vitro-Generated Prions by Inoculation to Hamster

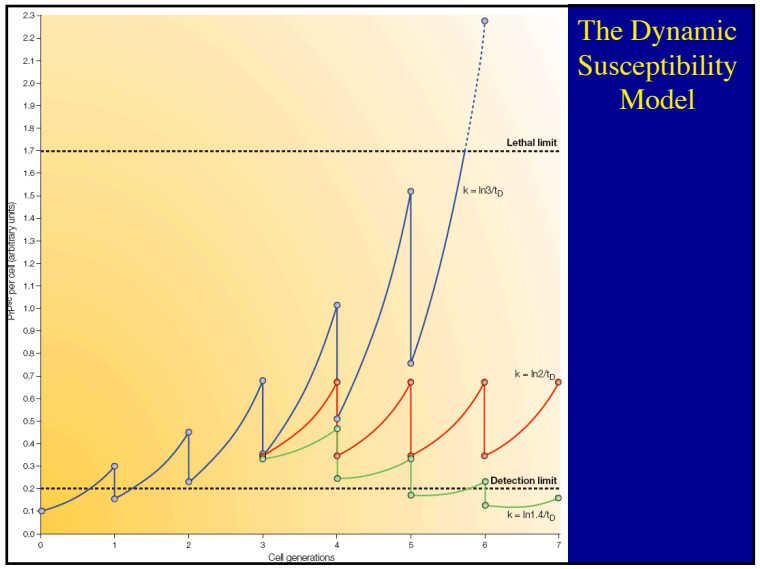
The conversion solution containing an excess of PrP^{C} (green circles) over the PrP^{Sc} seed (orange polygons) is subjected to multiple cycles of conversion and sonication/incubation. Such a system can replicate prion infinitely and efficiently in vitro. PrP^{Sc} aggregates grow by recruiting (incubation) and converting PrP^{C} into newly formed PrP^{Sc}, while in the sonication/incubation phase, PrP^{Sc} aggregates are fragmented into smaller aggregates (new seeds). This restarts the cycle overcoming the rate-limiting process of the in vitro PrP conversion associated with the original method. Gray boxes represent tubes.


Abnormal protein structures in the pathogenesis of neurodegenerative diseases
From: Yuan & Yankner (2000)
Nature 407, 802-809
Genetic mutation or environmental factors
Amyloid-β protien
Tau
Huntingtin
α-Synuclein
Fibrils
Dissociation from microtubules
Oligomers
Oligomers
Plaque
Neurofibrillary tangle
Nuclear inclusion
Lewy body
Alzheimer's disease
Frontotemporal dementia
Huntington's disease
Parkinson's disease


OVERVIEW OF NEURODEGENERATION
PD
HD
AD
MS
Other
Synuclein?
Excito-toxicity?
Amyloid? Tau?
Immune Response?
??
Protein Aggregation ?
Intervention?
Cell Death


Triggers
Primary responses
Pathology
Protein recruitment
Intranuclear aggregate
Aggresome
Nucleus
Cleavage
Misfolded protein
Chaperone mediated refolding
Inhibited UPS-mediated proteolysis
Native state
Mutations
Oxidative stress
Primary UPS dysfunction
Prion transmission
Ageing?
PD
Lewy body
AD
Plaque
Tangles
Prion
Plaque
ALS
Bunina bodies
PolyQ
Inclusions


The unfolded protein response (UPR), ubiquitin proteasome system (UPS) activation and its correlation with autophagy system
chaperone
alpha-synuclein
protein substrate
autophagy
ubiquitin
MEF2D
Hsp70
Hsp104
sHSPs
function promotion
HSPs
CMA Lamp-2a
Hsp90
Hsp70
activate
endosome
proteasome
CHIP
lysosome
glia
malfunction
protein aggregation
Hsp70
Inflammation in PD
Mutant SOD1 deposit in ALS
Lewy body in PD
Tau inclusion body in AD
Inclusion body in PolyQ diseases
Impairment of the degradation of insoluble proteins (that affect proper cellular functions) leads to NDs such as PD
CHIP: C terminal of molecular chaperone interaction protein; MEF2D: myocyte enhancer factor 2D; CMA: chaperone-mediated autophage



The Dynamic Susceptibility Model