Reflections of a Scientist with Parkinson's disease

Reflections – Why make this presentation ?

Parkinson's disease is characterized by the loss of dopamine-producing neurons.
For decades, patients have been told:
"The cause of dopamine neuron loss is unknown."

This statement is untrue.

- I am a non-medical research scientist with Parkinson's disease. I have applied my analytical and research skills to learn about the core events leading to the death of dopamine neurons.
- Fundamental research scientists agree that ***3 major events are known to contribute to neuron death.*** These events which occur inside neurons are: ***oxidative stress, mitochondrial dysfunction and inflammation.***
- Working with leading researchers, I have explored a well-known biological pathway that protects neurons from these events and developed a method to activate it and study its impact.
- **As things stand today:**
  - ***No drugs are approved to target these events which contribute to disease progression.***
  - ***Pharmaceutical drug development is biased towards the most profitable, symptomatic therapies, at the expense of those that could bring the most benefit to patients.***
- **We are People with Parkinson's and we need to change that.**

Ref: McFarthing et al, 2021

Reflections – Why should you be concerned ?

Parkinson's disease is a progressively debilitating and painful neurological condition.

It affects 10 million people worldwide and its prevalence is growing rapidly.

AND YET ...

Drug development for Parkinson's disease still remains biased towards symptomatic therapies, at the expense of disease-modifying therapies that could deliver greater benefit to patients.

- *No drugs have been developed to slow disease progression over the last 40 years.*
- All approved medications *only address dopamine deficiency.*

These attenuate some symptoms but have no effect on disease progression.

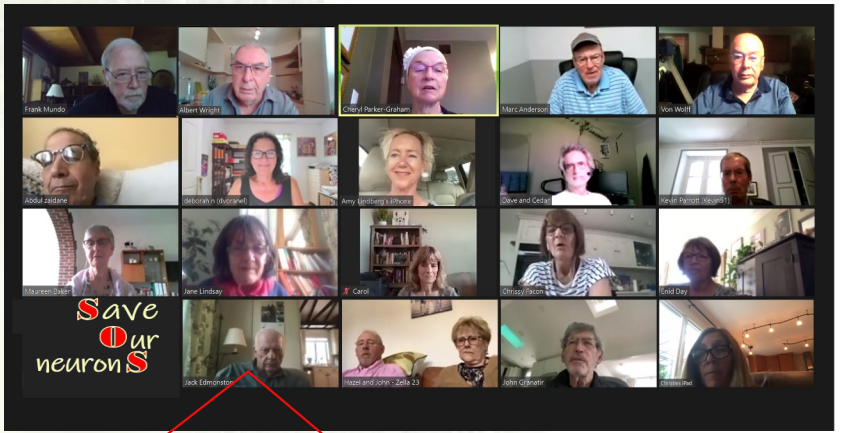
- Most drug development is carried out by private companies who select projects according to their own criteria. ***These include financial criteria.***
- There are *no financial incentives* to develop new drugs that would favor patient benefit over profitability.
- There are *financial disincentives* to develop *drugs using natural molecules* because these cannot be patented.
- ***If we exclude financial criteria*** and focus on the causes of PD as recognized by fundamental research, new targets and molecules for drug development open up. These include natural molecules to combat ***oxidative stress, mitochondrial dysfunction and inflammation in dopamine neurons and in astrocytes.***

That would be revolutionary

Ref: Parkinson's disease, Word Health Organisation, 2022

Reflections – inspired by shared concerns for human suffering

We've never met in person, but we know each other pretty well. About 20 of us chat regularly, sharing our experiences of Parkinson's disease on different continents. We've been meeting on Zoom ever since Marc set up regular meetings. It has become an essential rendez-vous for many of us. We chat about all things related to PD: sleeping; family relations; dealing with doctors; diets; food supplements; exercise; even dancing. Beyond the 20 regulars, there are another 30 or so who pop in from time to time.



We are PwP's
People with Parkinson's

What concerns us most is the lack of research on drugs to slow the progression of Parkinson's disease.

When I was diagnosed with Parkinson's disease in 2018, groups like this one taught me a lot about PD. Although none of us are medically trained, we have learned a lot about PD from each other. Together we have been searching for solutions to slow disease progression, because we know that drug companies have no incentive to develop drugs which target these early stages. As the only scientist in the group with research experience, I have studied Parkinson's disease both as a research scientist and as an observer of my own the disease.

Reflections – themes covered in this presentation

Reflections of a scientist with Parkinson's disease

Genesis

In the beginning ...

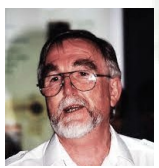
When I began my PhD research at Bristol University with the inspirational Prof. Alan Leadbetter, he handed me a heavy tome, the reference work on crystal structures at the time and asked me to "Make a list of things that don't look right". "If it doesn't look right, then presume that something is wrong", a good scientist does not accept inconsistencies. We chose the subject of my PhD research from that list.

Three years later we published the correct information in "Nature".

Alan's remarks immediately came to mind when my neurologist told me:

- *"The causes of Parkinson's disease are unknown" followed by*
- *"that's why there is no treatment to stop further progression".*

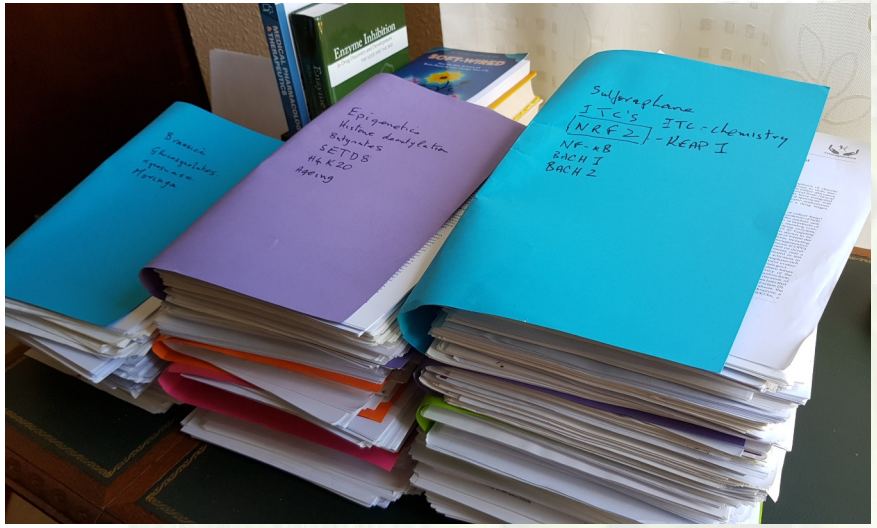
To the newly-diagnosed Person with Parkinson's, sitting on the wrong side of the learned Doctor's desk, this declaration of the absolute lack of knowledge was delivered with enough assurance to quell any argument. The "patient" in me remained respectfully silent, but the "scientist" in me immediately questioned the infinite scope of this knowledge vacuum. This admission of absolute lack of knowledge is widely promoted by institutions representing the collective wisdom of Parkinson's disease. Nevertheless, ***it didn't look right.***



"If it doesn't look right, then presume that something is wrong"
(Prof. Alan J. Leadbetter)

Ref: Leadbetter et al, Nature, 1973

Reflections – so many fields of research in PD, where does one start?



Open-source on-line publication now gives scientists access to peer-reviewed research as never before. In addition, powerful automated research tools, such as Google Scholar and ResearchGate have considerably accelerated and focused exploration of entire research fields. Collecting research data has never been so easy.

However, Parkinson's disease extends over many scientific disciplines. Choosing a good place to start looking is vital to avoid wasting time. And time is not my friend.

Knowing what causes Parkinson's disease should help towards finding a way to control it. PD web sites point out that a characteristic of PD is the death of dopamine-producing neurons in the mid-brain and by the time patients are diagnosed, up to 70% of them are thought to be dead. When I was diagnosed, my neurologist told me exactly that and added "The cause of the death of dopamine-producing neurons is unknown" – "that's why there are no drugs to slow the progress of PD".

Now that didn't seem right to me. The first claim was much too absolute and universal to be credible. That raised doubts about the validity of the second. This looked like a good place to start.

Reflections – Are the causes of Parkinson's disease totally unknown?

"Unknown" implies an absolute and universal lack of knowledge, I decided to check that out.

Open access, online-publication of research articles is now widespread, anyone can check this out. I learned that oxidative stress, inflammation and mitochondrial dysfunction, inside dopamine-producing neurons were widely recognized by fundamental researchers as the major contributors to neuron death in Parkinson's disease, although other factors (toxins, α-synuclein, genetic mutations, etc), could also be implicated. A 2018 paper by Guo et al. reviewed 139 publications in this field. They summed up their conclusions like this:*

The interaction between oxidative stress, mitochondrial dysfunction and neuroinflammation forms a positive feedback loop that drives the progressive loss of dopaminergic neurons in Parkinson's disease.

*Dr Ji-Dong Guo, Department of Neurology Beihua University, China,

This is not the whole story. We know there is more to it than that. But it should tell us which stages to target.

Guo's review and many similar articles tell us that the message should be much more positive:

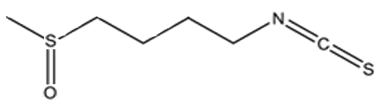
"We don't know everything about what causes neuron loss, but we know enough to start looking for ways to stop it."

Agnotology
is the science of knowledge, the absence of knowledge and doubt. Quoting false statements is used to cultivate doubt for political or financial gain.

Refs: Guo et al, 2018.

Research – Searching for the truth about Parkinson's disease

Better understanding made possible by great support from leading researchers



The transcription factor Nrf2, is a protein which promotes the expression of genes controlling oxidative stress in cells. It is known as the master regulator of redox homeostasis. Sulforaphane is an organic isothiocyanate, an electrophile (mild oxidant) that has been shown to activate this mechanism. Sulforaphane can be made by hydrolyzing the glucosinolate glucoraphanin. **I would like to express my sincere thanks** to Prof. Albena Dinkova-Kostova and Prof. Jed Fahey for their invaluable support in my quest to study PD using sulforaphane.

Cellular biology
The role of the transcription factor Nrf2 in counteracting neurodegenerative diseases

Prof. Albena Dinkova-Kostova
Professor of Chemical Biology
University of Dundee

Nutritional biochemistry
Optimizing the bio-availability of sulforaphane with active myrosinase

Prof. Jed W Fahey
Dir. Cullman Chemoprotection Center
Johns Hopkins Medical School (retired)

Multidisciplinary research
Applying sulforaphane to study Parkinson's disease

Dr Albert F Wright
Research Physicist
Institut Laue-Langevin, Grenoble (retired)

Research – The Nrf2 protein controls the transcription of neuro-protective genes

This gene transcription process controls oxidative stress inside many cell types – but not in neurons

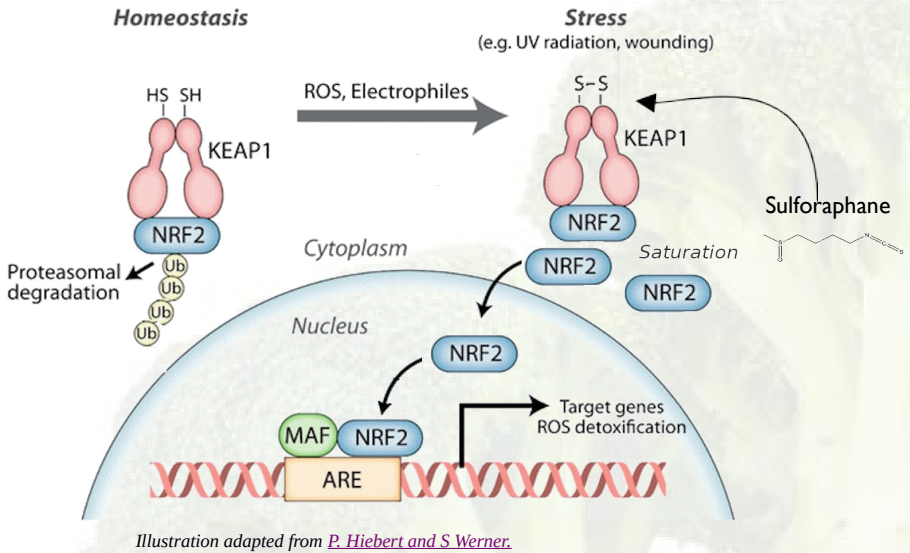


Illustration adapted from P. Hiebert and S Werner.

Prof. Albena Dinkova-Kostova
Professor of Chemical Biology,
University of Dundee

For neurons, it's more complicated than that. Due to epigenetic silencing of Nrf2 during neuronal maturation, Nrf2 cannot be activated directly in neurons. They are reliant on protection by Nrf2 in the surrounding astrocytes. In other words, activating Nrf2 in the brain protects neurons, but it is via the astrocytes.

When oxidative stress is low (homeostasis), the protein dimer Keap1 acts as a gatekeeper, captures free transcription factor Nrf2 and degrades it. This operation maintains the ideal quantity of free Nrf2 inside cells (left).

In healthy people, when oxidation levels rise due to increased oxygen and energy consumption, Keap1 is activated by highly-reactive oxidizing chemicals (ROS). This causes a change in conformation of Keap1 which blocks the degradation of the captured Nrf2. Newly synthesized Nrf2 is then free to migrate to the nucleus where it forms a hetero-dimer with MAF proteins and binds to ARE gene promoter sequences. This promotes the transcription of a battery of anti-inflammatory and antioxidant genes expressing antioxidant molecules and enzymes, and anti-inflammatory cytokines which protect cells from oxidative stress and inflammation.

With increasing age, the quantity of Nrf2 decreases and that of Keap1 increases. This altered ratio leaves cells more vulnerable to attack. Sulforaphane acts as an electrophile, temporarily binding to and inactivating Keap1. This enables increased transfer of Nrf2 to the nucleus and increased transcription of neuro-protective genes.

Refs: Dinkova-Kostova et al, 2018; Tonnelli, et al. 2018; Dinkova-Kostova et al. 2017; Zhang H, et al. 2015; Townsend B E et al, 2016; BELL K F S et al, 2015; Miyakasi I & Asanuma M, 2020.

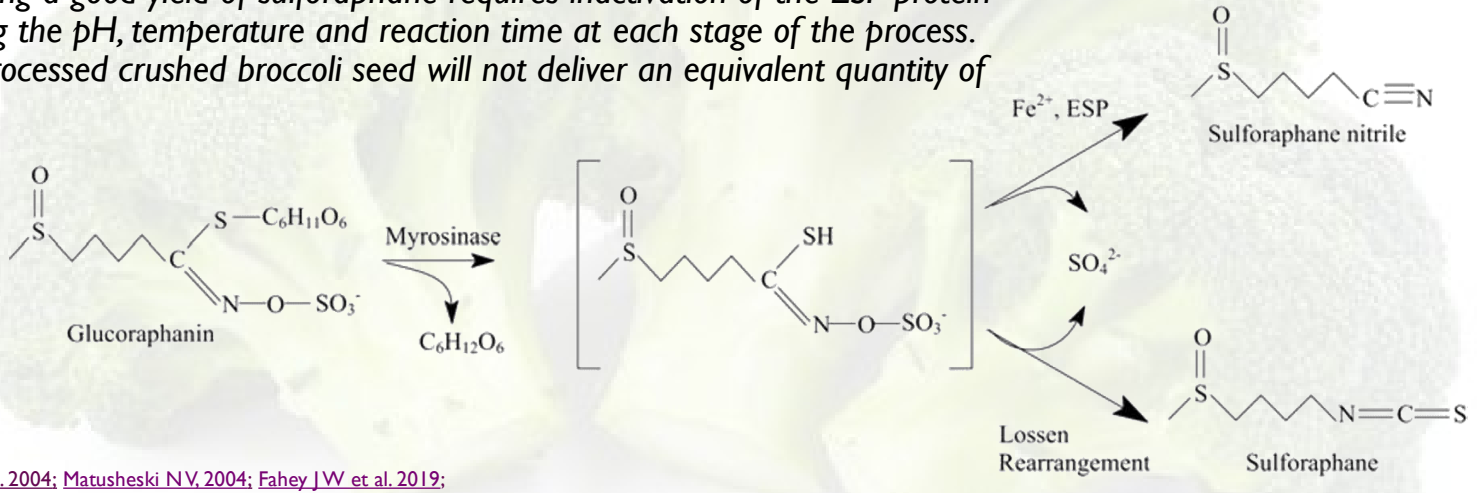
Research - one of the best sources of sulforaphane is broccoli seed

...but you have to get the processing conditions right

Broccoli seeds contain the glucosinolate glucoraphanin, an enzyme called myrosinase and an undesirable protein, ESP. Special varieties of broccoli have been developed to produce a high concentration of glucoraphanin, the precursor of sulforaphane.

Prof. Jed W Fahey
Nutritional biochemist
Baltimore

When the seeds are crushed and brought into contact with water, the enzyme myrosinase catalyses the hydrolysis of glucoraphanin to an unstable intermediary which can then rearrange to form either the active sulforaphane or an inactive sulforaphane nitrile. Obtaining a good yield of sulforaphane requires inactivation of the ESP protein and respecting the pH, temperature and reaction time at each stage of the process. Ingesting unprocessed crushed broccoli seed will not deliver an equivalent quantity of sulforaphane.



Refs: Bennet R N et al. 2004; Matusheski N V, 2004; Fahey J W et al. 2019;

Research – Sulforaphane, a formidable probe to study Parkinson's disease

Isothiocyanates finally meet Parkinson's disease

I was diagnosed with Parkinson's disease many years after retiring as a physicist from the Institut Laue-Langevin, (ILL) Grenoble. In this "Centre of excellence", one learns that it can take decades before knowledge of the leading scientists reaches the wider population. Having been told that the conditions causing Parkinson's disease were "unknown", I began research to find out if this was also true for the leading researchers. In doing so, I came across the inspiring work of Prof. Dinkova-Kostova at Dundee University, without doubt one of the leading experts on the transcription factor Nrf2, the master regulator of redox balance in cells. From that moment on I knew that "unknown" did not apply to everyone.

In 2019, my PD was severe and progressing rapidly. I was suffering from intense fatigue, poor balance, quiet voice, urinary incontinence, leg cramps, vivid dreams, neck and shoulder pain and tremor. I avidly read other works on how the protein Nrf2 controlled redox balance in cells and mitochondria and decided to explore this route. I learned that Prof. Jed Fahey in Baltimore was using broccoli sprouts to activate Nrf2 to treat Autism Spectrum Disorder. The link between broccoli and brain disorders is an isothiocyanate called sulforaphane. It activates Nrf2.

I obtained "Broccoli" seeds from a local organic food store and devised a method to make a broccoli seed tea. ***The effect of this tea was extremely rapid.*** *In 5 days I was on my feet again: no fatigue, no neck pain, no leg cramps, no urinary urgency, strong voice and great energy. I sent a note of my experience to Prof Dinkova-Kostova who invited Prof. Antonio Cuadrado into the loop. They asked about my source of seeds. The packet was labeled "Broccoli", but for these experts, the seeds were "Brassica rapa cymosa", and that is not broccoli. Prof. Richard Mithen from Aukland University added: "B. rapa seeds accumulate 3-butenyl glucosinolate, which will have produced 3-butenyl isothiocyanate. This is very similar to sulforaphane and very likely to have similar biological activity."*

This indicated to me that isothiocyanates could have a powerful effect on Parkinson's disease. Similar results were then obtained using a broccoli seed tea containing sulforaphane. My observations were shared with other PwPs who reported varying degrees of success. To overcome seed variability, Prof. Jed Fahey helped procure broccoli seeds with a high glucosinolate content. The variability of the sulforaphane (SFN) yield with respect to processing parameters remains to be determined. Spectroscopic analysis will be integrated into the project to resolve this (see Appendix).

The Nrf2/ARE redox regulator is inactive in DA neurons which makes them very vulnerable to oxidative stress (OS) and mitochondrial dysfunction. Neurons therefore depend on astrocytes to control OS and mitochondrial function. We observed that the Nrf2 activator SFN, rapidly reduced my PD symptoms, so what does it mean? Do astrocytes also suffer from OS and mitochondrial dysfunction? Was this being addressed by activating Nrf2 and if that was the case, were these conditions transmitted from astrocytes to neurons? Getting answers to these questions will be important not only for PD, but for all neurological diseases.

Three years on my PD appears to have stabilized. I now take the broccoli tea once a week. I have recovered my capacity to work long hours. My internal tremor has completely resolved and my energy levels are high. My left hand tremor is still occasionally present. At 81 I can climb mountains and play golf again. I still have PD, but life is pretty good again.

Dr Albert F Wright
Research physicist
Grenoble

Refs: Dinkova-Kostova, A T et al, 2018; Esteras N, et al, 2016; Vomund S, 2017; Exner N et al, 2012; Zimmerman A W et al, 2021; Bennet R N et al. 2004; Wright A F, 2021; Matusheski N V, 2004; Rappold P M & Tieu K, 2010; Sidoryk-wegrzynowicz M et al. 2010;

Research – the unexplored potential of plant-based molecules

By failing to meet the "business model criteria", research funding for plant-based molecules is handicapped.

- ***Prof. A. Cuadrado,*** a distinguished neuroscientist from Madrid demonstrated protection by sulforaphane on an animal model of Parkinson's disease in a study Funded by Michael J. Fox Foundation. (PMID: 21254817). They then applied for a new grant from the MJJF for a phase 2 clinical study in 2010. The study, called RASTOP (Rasagilin And Sulforaphane Therapy of Parkinsonism) was supported by 16 hospitals in several EU countries

"The study was not funded and the argument was that in the case that we would show a relevant efficacy, no company would be interested in covering the huge expense of going to the phase 3 trial with a natural compound that cannot be patented."
(A. Cuadrado, private communication).

They didn't discuss the potential benefit for patients.

What about the potential benefits for patients ?

- In 2021, I worked with ***Dr Simon Stott,*** Deputy Director of Research for Cure Parkinson's Trust, to prepare a research proposal for submission to the annual review committee of the International Linked Clinical Trials (iLCT). Our very detailed submission was based on a Broccoli Seed Tea, following the protocol that I had developed over 2 years to treat my own Parkinson's disease.

The committee rejected the proposal, partly because of the lack of pre-clinical data for this preparation but they also cautioned against over-activating the Nrf2 pathway, pointing out that dosing was a Goldilocks-like balancing act. It was also noted that NRF2 activators like sulforaphane can induce pro-oxidative states. There were some concerns regarding systemic delivery of an NRF2 activator.

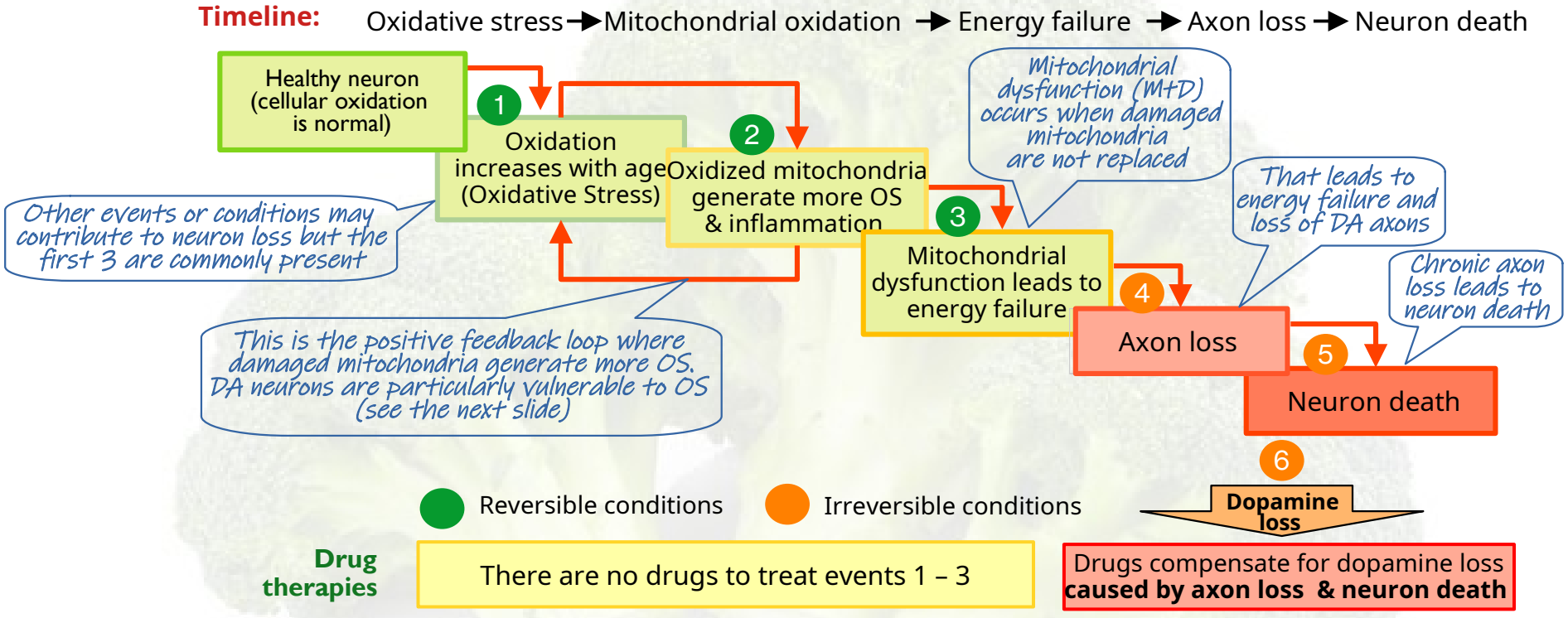
Nobody suggested it wouldn't work.

PWPs take a different view. Taking no action allows the disease to progress. We want the Nrf2 pathway to be properly researched.

Refs: Jazwa, A, et al. 2010; > Stott S & Wright A F, 2021;

Research – a model for the progressive loss of dopamine neurons

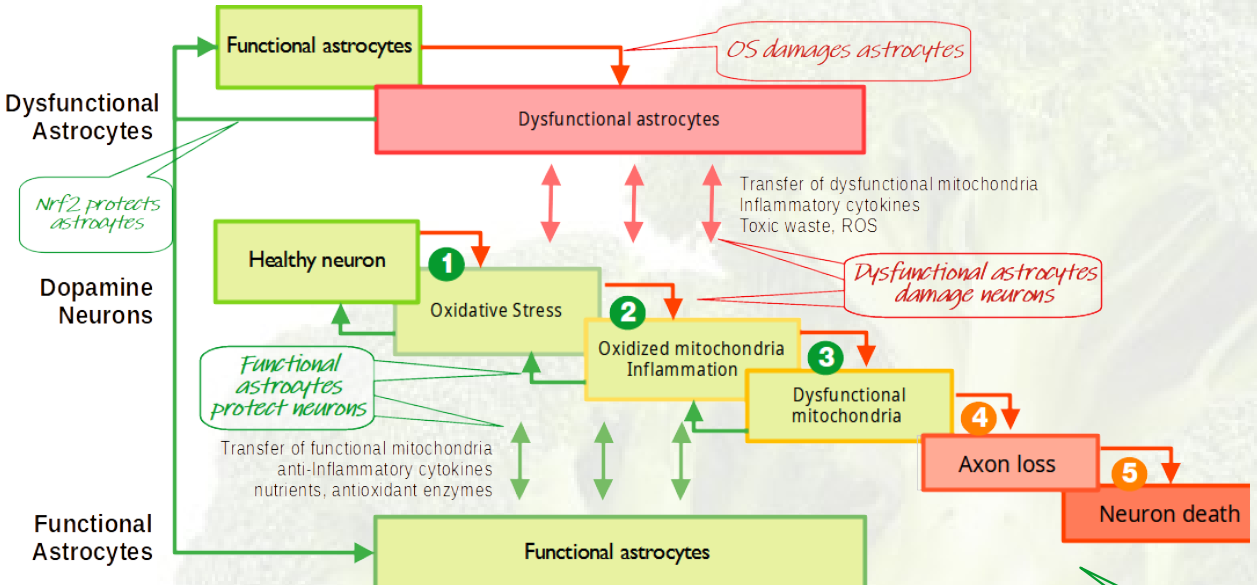
The first 3 events can be slowed or even reversed. Curiously, no drugs are available for these stages



Refs: Stanga S et al. 2020 ; Tagliaferro, P, Burke, R E. 2016; Suliman, H B & Piantadosi, C P. 2016: Picca, A et al. 2020. Jazwa, A. et al. 2010;

Research – redox balance in neurons is delegated to astrocytes

Healthy astrocytes protect neurons. Damaged astrocytes are toxic to neurons



Due to the very long distances from the DA nucleus to distal axons, waste removal and redox management cannot be handled efficiently from the nucleus. This makes DA neurons very vulnerable to oxidative stress. These functions are therefore carried out by astrocytes that act locally by exchanging molecules, waste products and nutrients across cell membranes.

Astrocytes also transfer fully-functional mitochondria to axons and synapses. This works well with fully functional astrocytes, but becomes toxic to neurons when astrocytes themselves suffer from oxidative stress and mitochondrial dysfunction.

Due to epigenetic silencing of Nrf2 during neuronal maturation, Nrf2 cannot be activated directly in neurons. Nrf2 is highly active in astrocytes. Neurons are reliant on protection by Nrf2 in the surrounding astrocytes. In other words, activating Nrf2 in the brain protects neurons, but it is via the astrocytes.

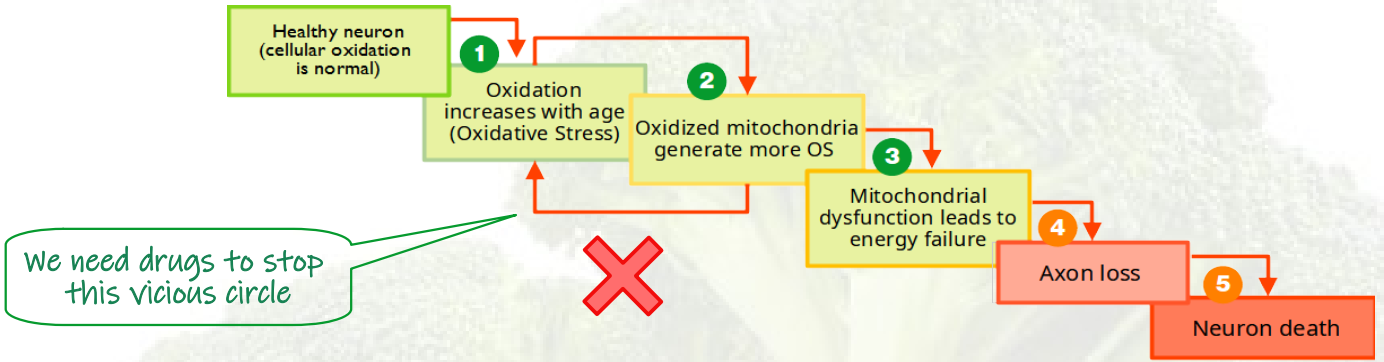
Nrf2 activation ensures the neuroprotective role of astrocytes

- Functional astrocytes protect DA neurons; damaged astrocytes cause neuron loss.
- The Nrf2 pathway is inactive in neurons but highly active in astrocytes
- Nrf2 activation can protect DA neurons indirectly by ensuring that astrocytes retain full functionality

Refs: Bantle C et al. 2021; Chen, P C, et al. 2009 Rose J et al. 2020 ; Zampeze E & Surmeier D J. 2020; Bell K F S et al. 2015 , Chen Y, et al, 2019 ; Lee K H et al. 2020 ; Lee K H et al., 2021 ; Mullica P et al., 2021 ; Kwon H S & Koh S-H, 2020 : Popa-Wagner A, et al, 2013 ; Ding Z-B et al, 2020 ; Chiarelli R A et al. , 2021; Bergstrom P et al., 2010 ;

Please take your time to read this page carefully. Every detail matters. It is precisely because astrocytes do the neurons' housekeeping that activating Nrf2 maintains redox balance in neurons via the astrocytes. Direct activation of Nrf2 in neurons would not be efficient because of the long distances from the nucleus to distal axons.

Reflections – Drug developers disregard the true needs of Parkinson patients



For People with Parkinson's

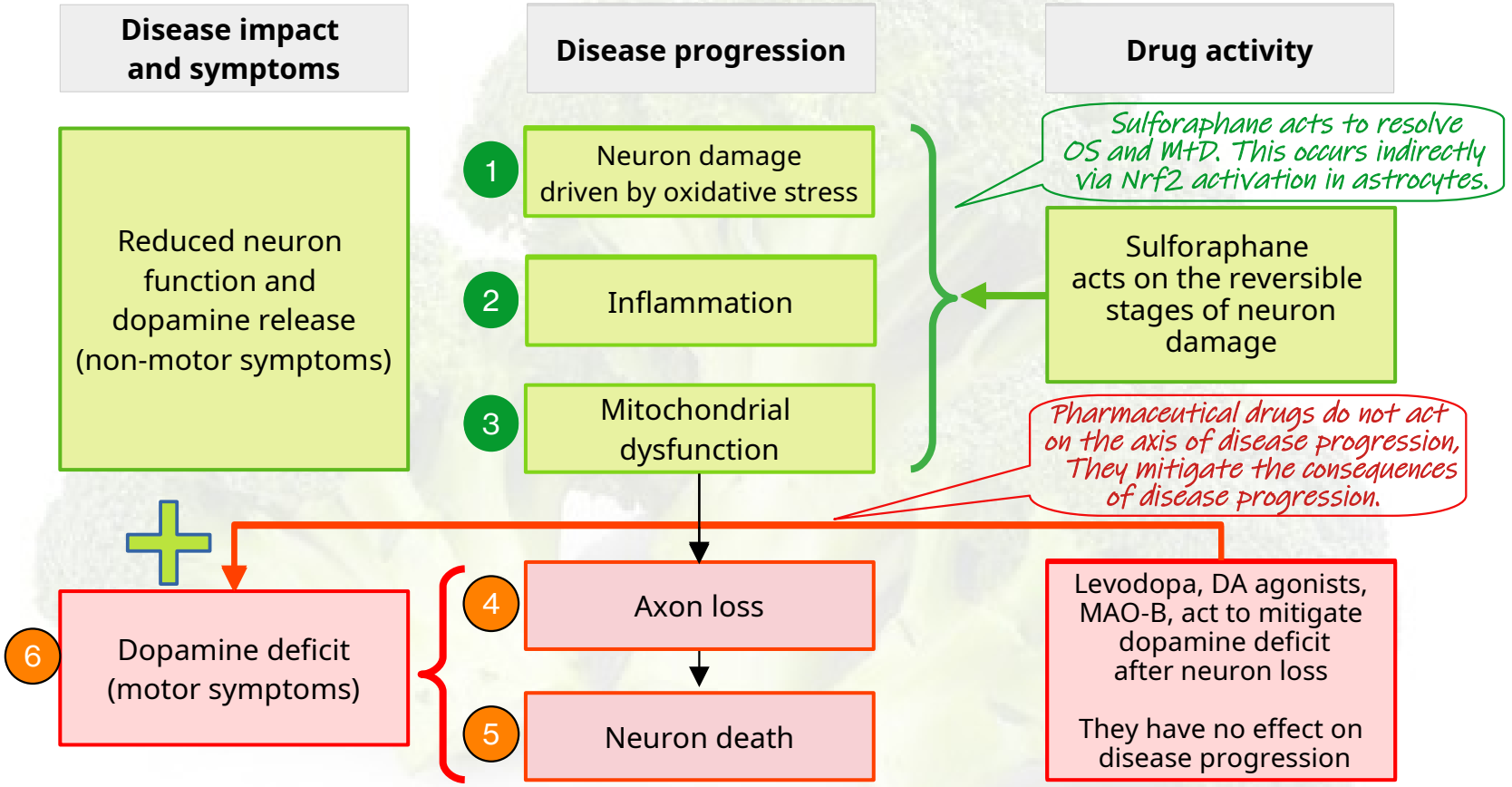
- Drugs to break the vicious circle of stages (1-2) would prevent neuron death and reduce dopamine loss at (6)
- Drugs to treat stages (1-3) would conserve neuron capacity and reduce the need for synthetic dopamine
- Sulforaphane can target all the events prior to neuron loss (1-3) by activating Nrf2 in astrocytes
- **These targets are disregarded by the Drug Industry. We call on Public Health Authorities to investigate this omission.**

For drug developers

- Revenues for current prescription drugs are generated by the consequences of neuron loss at (6)
- treating stages (1-3) would reduce revenues at (6)
- Unpatentable plant-based molecules are unprofitable for drug companies.

Reflections - Sulforaphane acts on all 3 processes leading to neuron death

In contrast, prescription drugs simply compensate for dopamine deficit after neuron death



Reflections – Isothiocyanates target many conditions in PD

but as plant-based molecules, they also present many practical challenges

Isothiocyanates	Potential targets	Challenges to be resolved
ITCs from Brassica species seeds	Neuron damage driven by oxidative stress	Plant source variations
Broccoli sprouts	Mitochondrial dysfunction	Processing variables
Broccoli Seed Tea	Inflammation	Reproducibility, Storage
		Clinical trials

The greatest challenge remains the high cost of clinical trials for plant products that cannot be patented. Logically, drug companies will not take on this cost. This is an issue for Public Health Authorities

Reflections - Drug companies have no incentive to use plant-based molecules

All drugs need to pass expensive clinical trials. But plant-based drugs cannot be protected.

Medication	Patented medication	Plant-based sulforaphane
Target activity in PD	Dopamine replacement only	Control of neurodegeneration
Impact on disease progression	None	May slow disease progression
Protected by patents	**YES**	**NO** Free to use
Required to pass Clinical Trials	**YES**	**As a drug, YES** **In food, NO**
Drug pricing	**Protected, expensive**	**Unprotected, inexpensive**

Authorization is required before medical professionals can prescribe a specific dose of sulforaphane for a designated medical condition.

No authorization required for people to eat foods containing an equivalent quantity of sulforaphane.

Reflections of a Scientist with Parkinson's disease

3 truths you should take away from this presentation

Fundamental researchers agree that disease progression in Parkinson's disease involves a cascade of events of these conditions:

- **Oxidative stress,**
- **Inflammation,**
- **Mitochondrial dysfunction**

These conditions are thought to occur in astrocytes and are then transferred to neurons.

Oxidative stress and mitochondrial dysfunction in astrocytes are therefore valid targets for PD.

Oxidative stress and mitochondrial dysfunction in astrocytes may be common to all neurological diseases. These conditions are not being targeted for any of them.

We are People with Parkinson's. We need more research on these targets

The people behind this initiative

Dr Albert Wright
Grenoble, France

Frank Mundo
Maine, USA

Scientific advisors

Prof. Albena Dinkova-Kostova
University of Dundee

Prof. Jed W Fahey
https://www.jedfahey.com

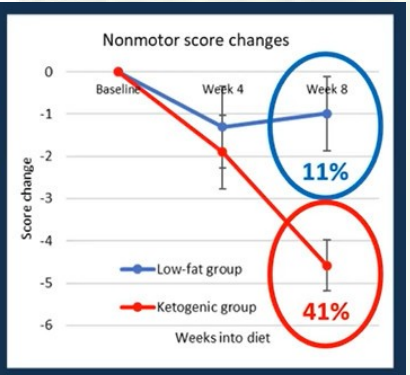
Reflections of a Scientist with Parkinson's disease

Targeting oxidative stress and mitochondrial dysfunction in Parkinson's disease

1- Fasting - Ketogenic diet

By the end of 8 weeks:

- Non-motor symptoms collectively improved in the ketogenic group…to both a statistically and clinically meaningful extent.
- Most improved were urinary dysfunction, pain, fatigue, sleepiness, and cognitive impairment, which are many of the most disabling, least levodopa-responsive symptoms.
- Motor symptoms and complications improved in both groups (possibly due to placebo effect and better diets in both groups compared to usual diets).



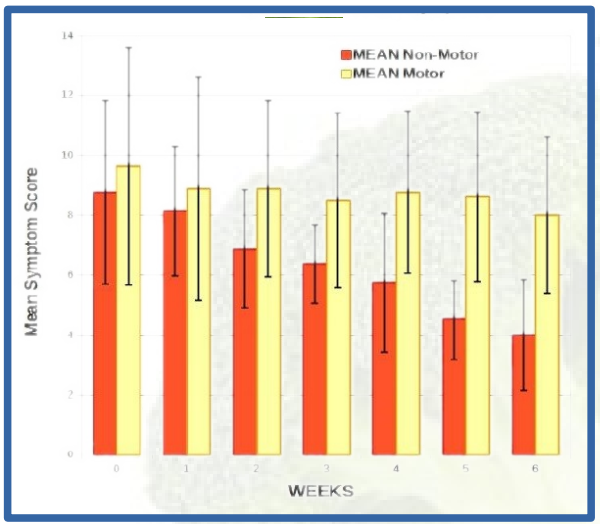
- Instead of making energy from glucose via Complex I respiration which generates more oxidative stress (OS), a ketogenic diet generates ketones which can be used to make energy via Complex II respiration which does not cause more OS.
- This breaks the vicious circle of [oxidative stress – mitochondrial dysfunction – oxidative stress – …]
- The ketogenic diet produced an unprecedented reduction in non-motor symptoms of 41% in just 8 weeks.

Phillips, M. C. L. et al. Low-fat versus ketogenic diet in Parkinson's disease: a pilot randomized controlled trial. Mov. Disord. 33, 1306–1314 (2018) https://movementdisorders.onlinelibrary.wiley.com/doi/full/10.1002/mds.27390

Reflections of a Scientist with Parkinson's disease

Targeting oxidative stress and mitochondrial dysfunction in Parkinson's disease

II – Activating the transcription factor Nrf2 by sulforaphane



Sulforaphane binds to Keap1, the negative regulator of Nrf2 which inhibits the degradation of captured Nrf2 by Keap1. Newly synthesized Nrf2, which is synthesized in large quantities, is then free to migrate to the nucleus where it binds to ARE gene promoter sequences.

This promotes the transcription of a battery of ~600 genes expressing anti-inflammatory cytokines and antioxidant molecules & enzymes which protect cells from oxidative stress and inflammation, the promote the renewal of mitochondria and the removal of mitochondrial waste. This process occurs in astrocytes which transfer the benefits of Nrf2 transcription and mitochondrial quality control over the whole neuron network.

- Nrf2 transcription attenuated a wide range of non-motor symptoms by more than 50 % in 6 weeks.
- The most improved symptoms were: urinary urgency, fatigue, brain fog, pain and sleep. Non-motor symptoms were barely changed.

https://www.researchgate.net/publication/351099763_A_pilot_study_of_a_broccoli-seed_tea_by_eight_Parkinson's_disease_patients

Reflections of a Scientist with Parkinson's disease

Targeting oxidative stress and mitochondrial dysfunction in Parkinson's disease

Fasting - Ketogenic diet

Activating the transcription factor Nrf2

} ***Identical attenuation of PD non-motor symptoms***

- ***Two entirely different approaches strongly attenuate non-motor symptoms of Parkinson's disease to the same degree and over the same short timescale.***
- ***Motor symptoms of Parkinson's disease are barely changed.***
- ***Both methods target oxidative stress and mitochondrial dysfunction.***
- ***The results are in agreement with established biological pathways***

Oxidative stress and mitochondrial dysfunction are valid targets to slow Parkinson's disease progression

Reflections of a scientist with Parkinson's disease

How does this affect the Quality of Life of people with Parkinson's disease?

Non-motor symptoms have a very serious impact on the quality of life of People with Parkinson's disease.

Click here to open this 2-minute video in your browser.

Refs: Bantle C et al. 2021; Chen, P C, et al. 2009 Rose J et al. 2020 ; Bell K F S et al. 2015 , Chen Y, et al, 2019 ; Mullica P et al., 2021 ; : Ding Z-B et al, 2020 ; Chiarelli R A et al. , 2021; Jazwa, A, et al. 2010;

On behalf of
People with Parkinson's

Thank you for your attention

About the author : Dr Albert F Wright is a Graduate of the Royal Institute of Chemistry and holds a PhD in Physical Chemistry from the University of Bristol. His post-doctoral career began with an appointment with the University of Oxford, detached to the Institut Laue-Langevin, Grenoble, which he later joined. Before retiring he was Scientific Assistant to the Director and Head of Communications at the Institut Laue-Langevin, Grenoble, the world's leading facility in neutron science & technology.