Project Notes:

Project Title: Evaluating the Effects of Curcumin-Coated Gold Nanoparticles on Survival and Motor Functions in a Parkinson's model of C. Elegans
Name: Hasini Gujjari

Contents:

Knowledge Gaps:

This list provides a brief overview of the major knowledge gaps for this project, how they were resolved and where to find the information.

Knowledge Gap	Resolved By	Information is located	Date resolved
How does autophagy exactly affect longevity and age-related diseases? Can this also alter its function in diseases of certain age	Reading journals about the effect of autophagy on longevity. It is noted that autophagy decreases as people	Google search/ nature.com	10/11/2024

groups?	age and can lead to age-related diseases		
Topic change: how do metallic nanoparticles affect C.elegans development?	Reading a couple of journals on the impact of gold and silver nanoparticles on C.elegans and looking into the factors of body length, brood size, worm population and locomotion (through the assays). There has been a slight and significant decreases in all the conditions.	Journal articles #6-9 although some studies were conducted using different model organisms, the information is consistent	10/6/2024
How are gold nanoparticles created?	By reading journals about the formulation of gold nanoparticles with curcumin	Journal entry 17	Week of Nov 11
What can we do to combat curcumin's bioavailability?	I read a journal regarding how to combat curcumin's poor solubility and its limited bioavailabilty.	Google Search/journal	12/11/2024

Literature Search Parameters:

These searches were performed between (Start Date of reading) and XX/XX/2019.
List of keywords and databases used during this project.

Database/search engine	**Keywords**	**Summary of search**
Nature.com	Autophagy in cancer	There are a lot of journals regarding the current

		research on autophagy in cancer. A lot of them talked about the dual role it plays in specific cancers and how it varies with each type of cancer. There are a lot of review articles if I read to gain a foundation on the topic.
ProQuest Science Database	C.elegans AND autophagy	I received journals and review articles regarding autophagy in C. elegans. One of them is in my project notes for A Term.
Nature.com	Autophagy mTOR	I received a list of journal articles that are related to targeting the mTOR signaling pathways for the development of potential cancer therapeutic treatments. This is used in the context of promoting and suppressing autophagy to achieve efficacy.

Nature.com	Nanoparticle toxicity	I receive a lot of journals but this time also including the environmental impacts. This is a broader search and encompasses a few engineering journals too.
ProQuest science database	Nanotoxity AND C.elegans	This is a very specific search because I am looking into toxicity in C.elegans. It worked and I got 2 articles that looked similar and interesting. They are about metal nanoparticles and their effects C.elegans toxicity – done through assays.

ProQuest Science Database	Curcumin AND neurons	I received articles about the therapeutic properties of curcumin.
Google	Curcumin in gold nanoparticles	I received articles about the effects of curcumin coated gold nanoparticles.
Science Direct	Parkinson's model C.elegans	I read a journal about how we can model parkinson's in c.elegans. This is where I found out about different assays, I could perform for my project including, lifespan, ROS levels, basal slowing response…etc.
Google	6-OHDA Parkinson's C.elegans	I got a couple of journals regarding 6-OHDA in c.elegans. These mention the neurodegeneration of dopamine neurons and how we can measure oxidative stress.

Tags:

Tag Name	
#intro	#nanotoxicity
#cancer	#C.elegans
#nanoparticles	#autophagy
#patent	#curcumin

#methodology	#neurotoxin
#parkinson	#assays
#Data Analysis	

Article #0 Notes:

Article notes should be on separate sheets

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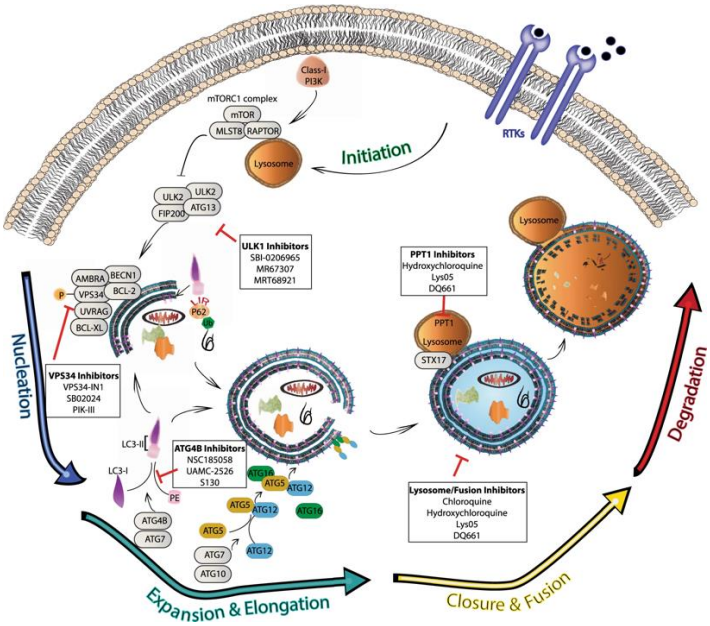
Source Title	
Source citation (APA Format)	
Original URL	
Source type	
Keywords	
#Tags	
Summary of key points + notes (include methodology)	
Research Question/Problem/ Need	
Important Figures	
VOCAB: (w/definition)	
Cited references to follow up on	
Follow up Questions	

Article #1 Notes: Autophagy in cancer: Moving from understanding mechanism to improving therapy responses in patients

Article notes should be on separate sheets

Source Title	Autophagy in cancer: Moving from understanding mechanism to improving

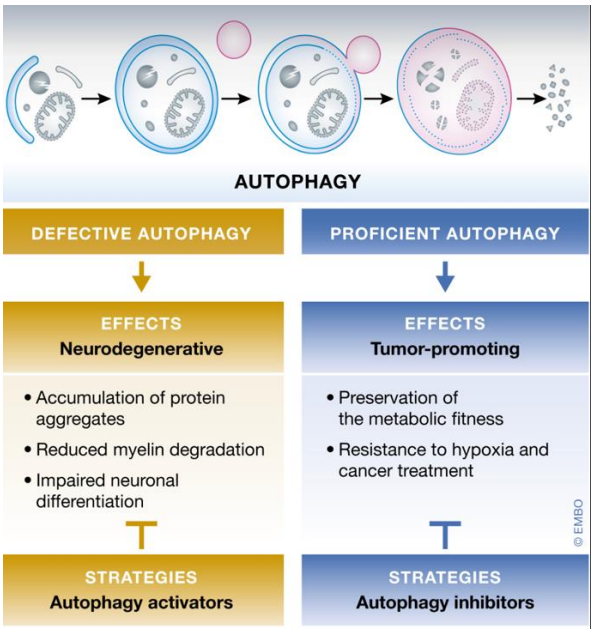
	therapy responses in patients
Source citation (APA Format)	Mulcahy Levy, J. M., & Thorburn, A. (2019). Autophagy in cancer: Moving from understanding mechanism to improving therapy responses in patients. *Cell Death & Differentiation*, *27*(3), 843–857. https://doi.org/10.1038/s41418-019-0474-7
Original URL	https://www.nature.com/articles/s41418-019-0474-7
Source type	Journal article
Keywords	Hypoxia (oxygen deprivation), cancer, tumor-inhibition, degradation process, CQ & HCQ (cancer treatments using inhibition of autophagy)
#Tags	#intro, #cancer, #autophagy
Summary of key points + notes (include methodology)	Autophagy plays a very important role in diseases, especially cancer, because it is a valuable survival mechanism for cancer cells and has to ability to suppress tumors too. Known for degrading cell material, autophagy has the potential to interact with apoptosis and serve in therapies. Targeting the late stages of autophagy is the current focus for future clinical trials of cancer patients as researchers are attempting to minimize consequences and drug failures.
Research Question/Problem/ Need	What are the different types of autophagy and what role does it play in cancer and its treatment process?
Important Figures	 5 stages of autophagy: clinical and pre-clinical targets are represented and the signaling pathways are described in the diagram.

VOCAB: (w/definition)	- Autophagosomes: a double membrane structure which plays a key part in macroautophagy and delivers cytoplasmic contents to the lysosome - T-cells: type of cells in immune system that fight infections and disease - Degradation: breakdown of biological components - Apoptosis: programmed cell death (normal part of cell cycle)
Cited references to follow up on	- Rao S, Tortola L, Perlot T, Wirnsberger G, Novatchkova M, Nitsch R, et al. A dual role for autophagy in a murine model of lung cancer. Nat Commun. 2014;5:3056. - Levy JM, Thorburn A. Targeting autophagy during cancer therapy to improve clinical outcomes. Pharmcol Ther. 2011;131:130–41.
Follow up Questions	How can we maximize the benefits of autophagy in the molecular level and minimize the progression of cancer? What are ways we can trigger autophagic cell death on cancer cells? Advanced drugs? How can we control autophagy's effects on tumor behavior using the pathways? How does blocking the autophagic pathway at different stages (initiation, nucleation, expansion, closure, degradation) effect tumor cell behavior?

Article #2 Notes: Autophagy in major human diseases

Article notes should be on separate sheets

Source Title	Autophagy in major human diseases
Source citation (APA Format)	Klionsky, D. J., Petroni, G., Amaravadi, R. K., Baehrecke, E. H., Ballabio, A., Boya, P., Bravo-San Pedro, J. M., Cadwell, K., Cecconi, F., Choi, A. M., Choi, M. E., Chu, C. T., Codogno, P., Colombo, M. I., Cuervo, A. M., Deretic, V., Dikic, I., Elazar, Z., Eskelinen, E., … Pietrocola, F. (2021). Autophagy in major human diseases. *The EMBO Journal*, *40*(19). https://doi.org/10.15252/embj.2021108863
Original URL	https://www.embopress.org/doi/full/10.15252/embj.2021108863

Source type	Review journal paper
Keywords	Cancer, neurodegeneration, inflammation (all vocab words too)
#Tags	#broadoverview #cancer #autophagy
Summary of key points + notes (include methodology)	Methodology is using mouse models in which the autophagy involved genes are deleted to find how exactly autophagy is involved in oncogenesis, immunotherapy, anti-cancer therapies, and tumor progression. Autophagy in cancer is mostly studied in heterozygous deletion models like *Becn1*$^{+/-}$ and the deletion of Atg genes. Results showed deletion of Atg and autophagy related genes in bladder cancer, bone cancer, breast cancer, prostate cancer and colorectal cancer resulted in the reduction of tumor growth and increased immunity.
Research Question/Problem/ Need	How is autophagy dysfunction connected to major human disorders?
Important Figures	 Figure 2. **Basic principles of autophagy modulation as a therapeutic strategy for human disease**
VOCAB: (w/definition)	Neoplastic lesions: abnormal tissues that form when cells malfunction and don't die when they are supposed to pro-oncogenic stimuli: genes that can cause the growth of cancer cells OIS (Oncogene-induced senescence): very powerful tumor suppressive mechanism which stops the cell cycle when alterations in the genome begin Malignancies: cancer cells which have the ability to spread throughout the body (metastasize) and infect tissues BENC1: gene related to autophagy induction and suppression of tumors

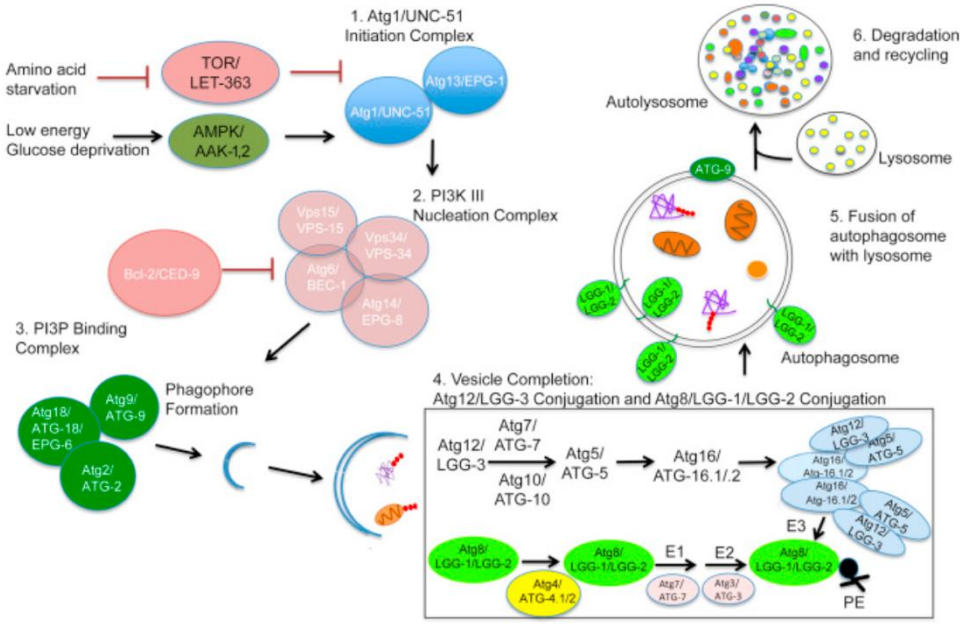
	Proteostasis: biological pathway of proteins (folding, degradation)
Cited references to follow up on	- Kimmelman AC, White E (2017) Autophagy and tumor metabolism. *Cell Metab* 25: 1037–1043 - Larionova I, Cherdyntseva N, Liu T, Patysheva M, Rakina M, Kzhyshkowska J (2019) Interaction of tumor-associated macrophages and cancer chemotherapy. *Oncoimmunology* 8: 1596004
Follow up Questions	How can we target and activate CMA to increase chances of tumor suppression? What impact does autophagy have on infectious diseases or virology? Does autophagy interact with viruses or antibodies/immune system?

Key Points:

- Mutations in the autophagy processes can cause pathologies
- Autophagy increases longevity, prevents neoplastic transformation of healthy cells, essential for OIS activation and stop the pro-oncogenic stimuli; many factors: tumor type, disease stage, host factors
- Molecular pathways in which cellular components are pushed to the lysosomes for degradation and recycling
- 3 types: macro autophagy (cellular components become isolated in a double-membraned vesicle which is the autophagosome).
- Deletion of Ambra1, suppression of Atg5 and Atg7 in specific cancerous organs have showed to increase the tumor lesions
- CMA (chaperone-mediated autophagy) leads to prevention of malignant transformation in the body as mouse models with selective blockage of CMA in liver show higher rates of decreasing malignancy
- CMA promotes degradation of pro-oncogenic proteins like MYC, TPT1/TCTP and MDM2 – increasing immune response
- Against inflammation: disposing not functioning mitochondria, damaged proteins like protein aggregation, degradation of inflammasomes
- Inhibition of autophagy is difficult because cancer cells need metabolism in the tumor environment
- Upregulation of NFE2L2/NRF2 beats the loss of autophagy in tumors
- In specific cancers, blocking CMA reduces tumor size

Article #3 Notes: Autophagy in *C. elegans* development

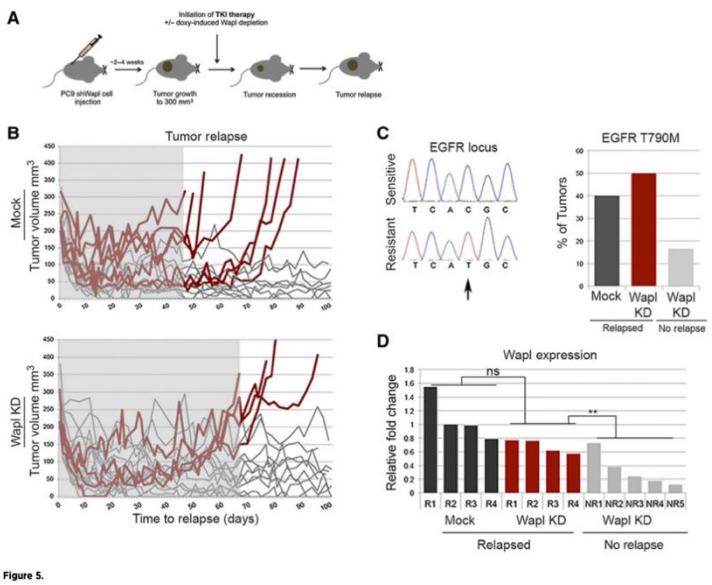
Source Title	Autophagy in C.elegans development
Source citation (APA Format)	Palmisano, N. J., & Meléndez, A. (2018, April 27). *Autophagy in C. elegans development*. Developmental Biology. https://www.sciencedirect.com/science/article/pii/S0012160617306127
Original URL	https://www.sciencedirect.com/science/article/pii/S0012160617306127
Source type	Website
Keywords	TOR signaling pathway, induction, vesicle nucleation, vesicle elongation, protein aggregation
#Tags	#C elegans #autophagy
Summary of key points + notes (include methodology)	There are 3 types of autophagy: macroautophagy, chaperone-mediated autophagy and microautophagy. Autophagy is triggered in response to various stresses like nutrient deprived, increased temp and protein aggregation. It's a quality control system that helps with homeostasis and can help with miRNA-mediated silencing. - Required for dauer development to occur and properly finish - Important for synapse formation and germ cell proliferation - Interacts with signaling pathways like apoptosis, stress response, metabolism, cell regulation, development - Autophagy is overall controlled by many genes that are expressed in the review cycle chart - Essential for embryogenesis, development
Research Question/Problem/ Need	How does autophagy assist in the developmental cycle of C. elegans?

Important Figures	 This figure describes the development and the process of autophagy in C.elegans with the proteins and signaling pathways involved.
VOCAB: (w/definition)	Lipophagy: a form of autophagy that selectively engulfs the cellular components C. elegans: Caenorhabditis elegans is a model organism used for research Dauer development: a specialized stress-resistant developmental cycle of C.elegans
Cited references to follow up on	A. Alberti, X. Michelet, A. Djeddi, R. Legouis The autophagosomal protein LGG-2 acts synergistically with LGG-1 in dauer formation and longevity in C. elegans Autophagy, 6 (2010) K. Ames, A. Meléndez Non-autonomous autophagy in germline stem cell proliferation Cell Cycle (2017), pp. 1-2
Follow up Questions	What other factors effect autophagy drastically in the developmental process of C.elegans? How does autophagy dysfunction result in the other human immune diseases? How was autophagy affect the development signaling pathways while integrating environment conditions in cancers and neurological diseases?

Article #4 Notes: Suppression of Chromosome Instability Limits Acquired Drug Resistance

Article notes should be on separate sheets

Source Title	Suppression of Chromosome Instability Limits Acquired Drug Resistance
Source citation (APA Format)	Crowley, E. A., Hermance, N. M., Herlihy, C. P., & Manning, A. L. (2022). Suppression of chromosome instability limits acquired drug resistance. *Molecular Cancer Therapeutics*, *21*(10), 1583–1593. https://doi.org/10.1158/1535-7163.mct-22-0263
Original URL	https://aacrjournals.org/mct/article/21/10/1583/709523/Suppression-of-Chromosome-Instability-Limits
Source type	Journal
Keywords	Assays: tests to find to measure the amount of specific substances Taxol: microtubule stabilizing drug nCIN: numerical chromosome instability which means that the cells are gaining and losing entire chromosomes leading to an abnormality Wapl: negative regulator of cohesion complex
#Tags	#ProfessorJournals
Summary of key points + notes (include methodology)	Role of nCIN in non-small lung cancer was tested. The study found that chromosome segregation errors in the NSCLC cells correspond to the enhanced localization of Aurora B using immunofluorescence microscopy and finding the NH levels and lagging chromosomes data. nCIN influences the process of acquired drug tolerance because without it, mutations will dominate and promote more tumors. nCIN has also been linked to several other disorders and conditions – meaning that targeting it and suppressing it may benefit tumor treatment and progression rates. Methodology involved detecting proteins and confirming their depletion, immunofluorencence and fluorescence in situ hybridization (FISH), growth and survival analyses, EGFR sequencing and tumor growth and relapse assays.
Research Question/Problem/ Need	What are the impacts and effects of nCIN suppression in drug resistance? How does the Aurora B kinase effect chromosome segregation activity?
Important Figures	

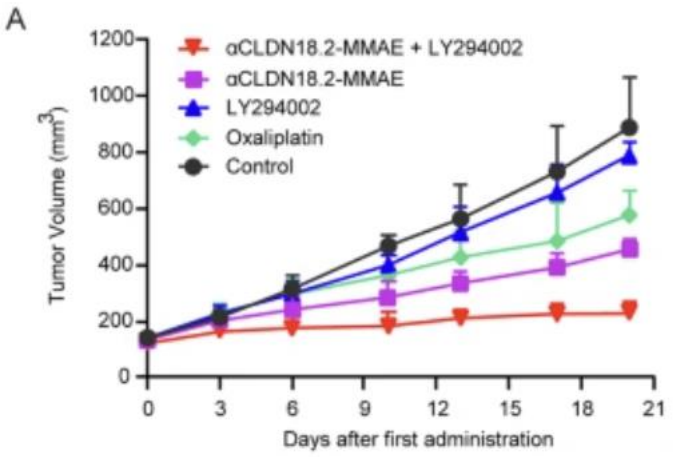
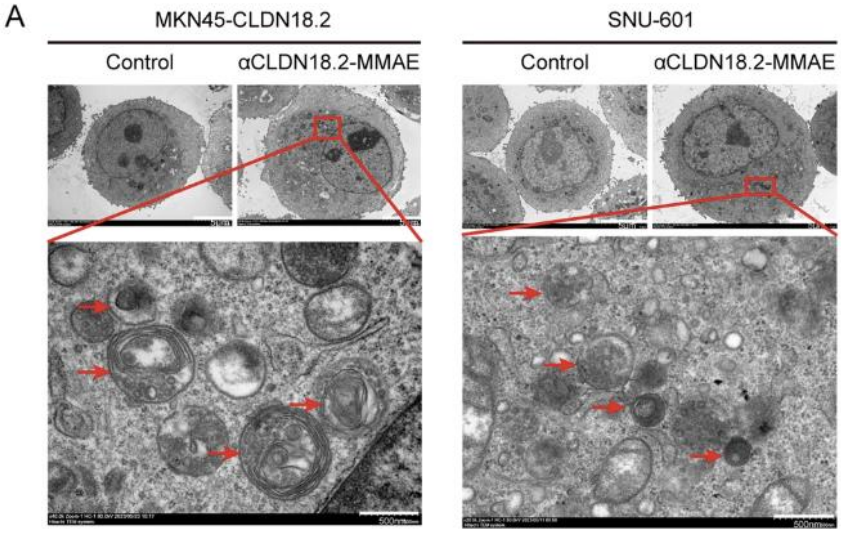
	 Figure 5. With the inclusion of Wapl KD, the percentage of relapsed tumors increases and the volume corresponds.
VOCAB: (w/definition)	nCIN: numerical chromosome instability aneuploidy: abnormal number of chromosomes in a haploid microtubules: search and bind chromosomes (segregation of DNA) Kinetochores: large protein that connects chromosomes to microtubules of the mitotic spindles
Cited references to follow up on	Baker DJ , Jin F , Jeganathan KB , van Deursen JM . Whole chromosome instability caused by Bub1 insufficiency drives tumorigenesis through tumor suppressor gene loss of heterozygosity. *Cancer Cell* 2009;16:475–86. McClelland SE , Burrell RA , Swanton C . Chromosomal instability: a composite phenotype that influences sensitivity to chemotherapy. *Cell Cycle* 2009;8:3262–6.
Follow up Questions	How exactly does instability of chromosomes contribute to drug resistance in tumors? Do you know of any drugs or therapies that could be designed to target CIN in tumors? Has there been more research done on this after the journal was published?

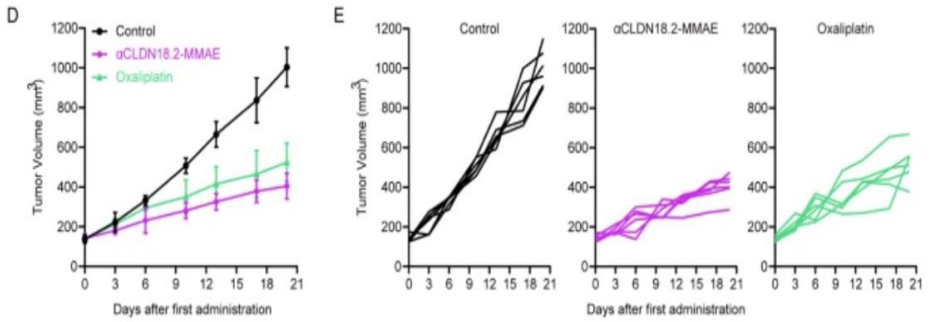
- CIN promotes gene diversity, delay in drug response, tumor aggressiveness, evolution and relapse
- CIN occurs from errors and defects in mitosis segregation process
- Defects in chromosome segregation that alter the stability of microtubules attachments can lead to nCIN

- Aurora B Kinase is a regulator of kinetochore-microtubule dynamics during mitosis process (overexpression leads to aneuploidy)

Article #5 Notes: Enhancing antitumor efficacy of CLDN18.2-directed antibody-drug conjugates through autophagy inhibition in gastric cancer

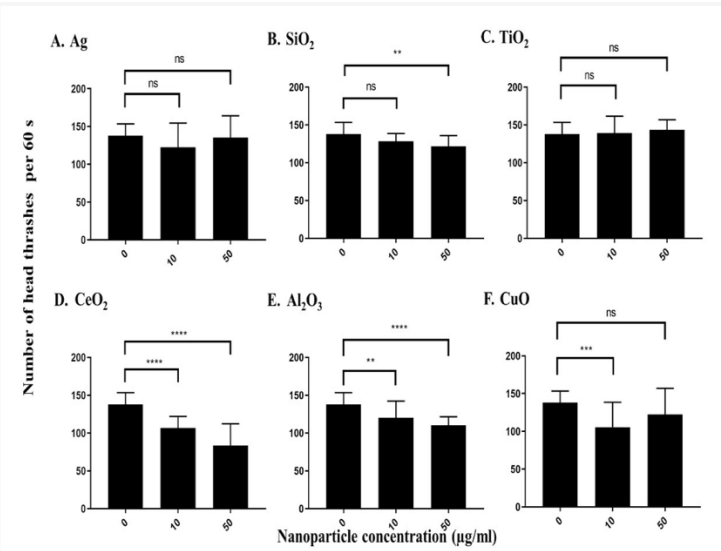
Source Title	Enhancing antitumor efficacy of CLDN18.2-directed antibody-drug conjugates through autophagy inhibition in gastric cancer
Source citation (APA Format)	Xue, W., Xu, C., Zhang, K., Cui, L., Huang, X., Nan, Y., Ju, D., Chang, X., & Zhang, X. (2024). Enhancing antitumor efficacy of CLDN18.2-directed antibody-drug conjugates through autophagy inhibition in gastric cancer. *Cell Death Discovery*, *10*(1). https://doi.org/10.1038/s41420-024-02167-0
Original URL	https://www.nature.com/articles/s41420-024-02167-0#citeas
Source type	Journal
Keywords	Cytotoxicity, efficacy, CLDN18.2, autophagy, apoptosis, ACD
#Tags	#autophagy
Summary of key points + notes (include methodology)	The objective of the study was to combine autophagy inhibitors with CLDN18.2-directed anti-body drug conjugates to create a therapeutic approach to treat gastric cancer. First, they tested if aCLDN18.2-MMAE does in fact demonstrate anti-tumor efficacy against the positive aCLDN18.2 gastric cancer cells. The cells were given a specific amount of drug concentration and recorded through xenografts conducted on the cells implanted in mice – results showed increased potent cytotoxicity against the cancer cells. Next, apoptosis and autophagy processes were also found to be activated by this ACD due to the microscopy displaying autophagosome vesicles. Furthermore, flow cytometry charts prove that a significant amount of apoptosis was induced when the treatment combined autophagy inhibitor LY294002 and aCLDN18.2. Shockingly, tumor suppression rate became as high as 74.2% during the combined treatment.

	This is essentially a knowledge gap that the researchers have filled with this study that will aid in the development of therapeutic drugs.
Research Question/Problem/ Need	How does CLDN 18.2-directed ADC affect gastric cancer and what are the results once autophagy is also inhibited?
Important Figures	 Shows how the ACD and the autophagy inhibitor combined therapy gives best results on anti-tumor efficacy  The red arrows show the formations of autophagosomes during the treatment – indication of autophagy

	 Compared to the control, the tumor volume significantly decreases with the drugs.
VOCAB: (w/definition)	Epitopes: components of immunogenic molecules that attach themselves to a complementary site of an antibody Cytotoxicity: ability of a substance to cause damage or potentially kill cells Ubiquitination: process in homeostasis that involves removing unwanted or damaged proteins; ATP dependent Augmentation: increasing in size, value or quality of something Immunoblotting: methodology that identifies proteins using antibodies
Cited references to follow up on	Yu J, Fang T, Yun C, Liu X, Cai X. Antibody-drug conjugates targeting the human epidermal growth factor receptor family in cancers. Front Mol Biosci. 2022;9:847835. Russell RC, Guan KL. The multifaceted role of autophagy in cancer. EMBO J 2022;41:e110031.
Follow up Questions	Does targeting another protein of high localization in gastric cancer cells show any different findings? What happened to the tumor cells proliferation rates and relapse rates during and after combined treatment? Would the same methodology such as using ACDs and the process as a whole prove to work for other types of cancers?

Article #6 Notes: Comprehensive phenotyping and transcriptome profiling to study nanotoxicity in *C. elegans*

Source Title	Comprehensive phenotyping and transcriptome profiling to study nanotoxicity in *C. elegans*
Source citation (APA Format)	Viau, C., Haçariz, O., Karimian, F., & Xia, J. (2020). Comprehensive phenotyping and transcriptome profiling to study nanotoxicity in C. elegans. *PeerJ*, *8*. https://doi.org/10.7717/peerj.8684
Original URL	https://peerj.com/articles/8684/
Source type	Journal
Keywords	Nanoparticles, neurotoxicity, Growth inhibition, locomotion velocity, reproduction
#Tags	#neurotoxicity
Summary of key points + notes (include methodology)	Smaller particles are more reactive and are capable of being more toxic. After the preparation of nanoparticles, assays were performed regarding each of the mentioned factors. The results proved that as the concentration of Ag increases, there is a decrease in locomotion velocity. For TiO2, there was an increase at 10 µg/ml which was unexpected. CeO2 nanoparticles had no effect on the locomotion. For body length, Ag and SiO2 nanoparticles prove to be similar regarding their toxicities as they were the only ones that had a significant change. The reproduction assay resulted in all nanoparticles except Al2O3 showing a significant decrease in brood size – most proving to be an inhibitor of *C. elegans*. For neurotoxicity assays, Ag, SiO2, and TiO2 showed no significant effects while CeO_2, Al_2O_3 and CuO expressed a change in number of head thrashes per 60secs. Gene set enrichment analysis was done on Ag and SiO2 to rank their involvement in biological processes and pathways. Nanoparticle exposure is linked to the human immune system and there were a lot of similarities in the down-regulated genes between SiO2 and Ag except innate immunity.
Research Question/Problem/ Need	How do the Ag and 5 other metal oxide nanoparticles affect the factors of locomotion, velocity, growth, reproduction and neurotoxicity?
Important Figures	

	 **Figure 4: Neurotoxicity of various nanoparticles (A, Ag; B, SiO_2; C, TiO_2; D, CeO_2; E, Al_2O_3; and F, CuO) to *C. elegans* N2 at 0, 10 and 50 µg/ml.** The graph explains the neurotoxicity of various nanoparticles to C.elegans at different concentrations.
VOCAB: (w/definition)	BP: biological processes Downregulation: suppressing a response to stimulus
Cited references to follow up on	• Boraschi D, Italiani P, Palomba R, Decuzzi P, Duschl A, Fadeel B, Moghimi SM. 2017. Nanoparticles and innate immunity: new perspectives on host defence. *Seminars in Immunology* 34:33-51 • Kaletta T, Hengartner MO. 2006. Finding function in novel targets: *C. elegans* as a model organism. *Nature Reviews. Drug Discovery* 5(5):387-398 • Khanna P, Ong C, Bay BH, Baeg GH. 2015. Nanotoxicity: an interplay of oxidative stress, inflammation and cell death. *Nanomaterials* 5(3):1163-1180
Follow up Questions	How do the conclusions and results stated in the study be used for our understanding of the immune system or other human diseases and functions? How can we manually decrease toxicity in model organisms? How can toxicity impact diseases and infections? Are they being taken into account in the current treatments?

Article #7 Notes: *C. elegans* monitor energy status via the AMPK pathway to trigger innate immune responses against bacterial pathogens

Source Title	C. elegans monitor energy status via the AMPK pathway to trigger innate immune responses against bacterial pathogens
Source citation (APA Format)	Ju, S., Chen, H., Wang, S., Lin, J., Ma, Y., Aroian, R. V., Peng, D., & Sun, M. (2022). C. elegans monitor energy status via the AMPK pathway to trigger innate immune responses against bacterial pathogens. *Communications Biology*, *5*(1). https://doi.org/10.1038/s42003-022-03589-1
Original URL	https://www.nature.com/articles/s42003-022-03589-1
Source type	Journal
Keywords	Immune system, pathogens,
#Tags	#C.elegans
Summary of key points + notes (include methodology)	Bt is a type of pathogen which produces the Cry toxin is used in C.elegans to test and identify the physiological changes after Bt infection. The results showed that the metabolic pathway was impacted the most, creating an energy imbalance which indicates mitochondrial disruption. The Cry5Ba toxin plays a major role in manipulating host cell mitochondria and causing damage. After looking into the calcium and potassium levels cellularly after Bt infection, it was clear that there was a potassium leakage due to Cry5Ba as there was a decrease in the K+ ion. Due to K+ leakage, there was mitochondrial stress which then caused the energy imbalance. A decrease in energy levels can activate the AMPK of C. elegans because of Bt infection. The activity of AMPK then regulates immune responses such as the DAF-16-dependent signaling pathway as the defense mechanism. The toxin Cry5Ba could have led to the mitochondrial damage indirectly because the colocalization test confirmed that there was no direct contact – instead the leakage of potassium did. This study was done with multiple assays, western blotting analysis, PCR analysis, Ca & K imaging and worm preparation.
Research Question/Problem/	What are the mechanisms behind how the cell surveillance systems in C.

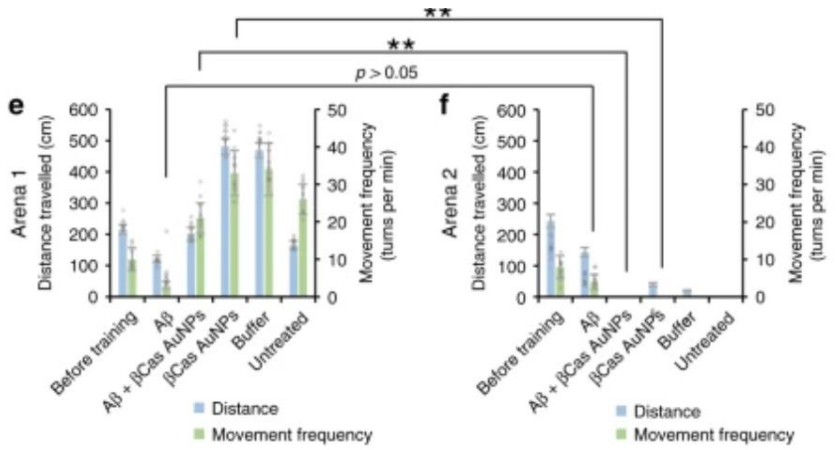
Need	elegans senses pathogens and as defense, activates the immune response?
Important Figures	None
VOCAB: (w/definition)	MAMPs: microbe-associated molecular patterns DAMPs: danger-associated mol. Patterns ETI: known as effector-triggered immunity where hosts can sense damage or certain factors that can help them discriminate pathogens PPR: pattern-recognition receptors PTI: pattern triggered immunity
Cited references to follow up on	- Pukkila-Worley, R. Surveillance immunity: an emerging paradigm of innate defense activation in *Caenorhabditis elegans*. *PLoS Pathog.* **12**, e1005795 (2016). - Liu, Y., Samuel, B. S., Breen, P. C. & Ruvkun, G. *Caenorhabditis elegans* pathways that surveil and defend mitochondria. *Nature* **508**, 406–410 (2014).
Follow up Questions	Study mentioned that the toxins produced by P. aeruginosa and L. monocytogene might work differently. How are they different? Change in calcium levels are usually associated with the activation of AMPK pathway. How is the finding that the potassium leakage significant to our knowledge of the AMPK signaling pathway? Is it still reacting the same to K+? Is there anything different about it?

Article #8 Notes: Inhibition of amyloid beta toxicity in zebrafish with a chaperone-gold nanoparticle dual strategy

Article notes should be on separate sheets

Source Title	Inhibition of amyloid beta toxicity in zebrafish with a chaperone-gold nanoparticle dual strategy
Source citation (APA Format)	Javed, I., Peng, G., Xing, Y., Yu, T., Zhao, M., Kakinen, A., Faridi, A., Parish, C. L., Ding, F., Davis, T. P., Ke, P. C., & Lin, S. (2019). Inhibition of amyloid beta toxicity in zebrafish with a chaperone-gold

	nanoparticle dual strategy. *Nature Communications*, *10*(1). https://doi.org/10.1038/s41467-019-11762-0
Original URL	https://www.nature.com/articles/s41467-019-11762-0
Source type	Journal
Keywords	Chaperone proteins, gold nanoparticles, zebrafish, Alzheimer's, neural functions, toxicity
#Tags	#nanoparticles #nanotoxicity
Summary of key points + notes (include methodology)	Background: - Aggregation of amyloid fibrils and plaques lead to many neurological diseases such as AD - Oligomers are known to be toxic and induce failed autophagy, inflammation and more - AB is a peptide that originates from amyloid precursor protein - Nanoparticles can act as inhibitors, designed to be minimally toxic and getting across the BBB well - B casein and a casein proteins act as chaperones in the process Methodology + Key points: Using chaperone proteins and combining it the use of gold nanoparticles leads to the inhibition of AB aggregation and therefore, decreasing AB toxicity levels. AB is connected to neurodegeneration. - Bcas (chaperone activity) was coated on gold nanoparticles and made into 5mm for proper BBB translocation - AB and BcasAuNPs were put inside the zebrafish by cerebroventricular and intracardiac injections - Interactions between BcasAuNPs and AB oligomers were studied because oligomers and protofibrils indicate toxicity uding microscopy and assays - Incubated BcasAuNPs with Abo (oligomers) and ABm (monomers) and TEM imaging showed high affinity of BcasAuNP for ABo - DMD simulations were done to test if the replacement of Bcas corona with AB was favorable; it in fact, was not - After AB was injected in the zebrafish, reductions and movement distance and frequence was noticed and confirmed with fluorescence techniques (AB fibrils) - Helium ion microscopy confirmed that the damage induced by AB to the SH-

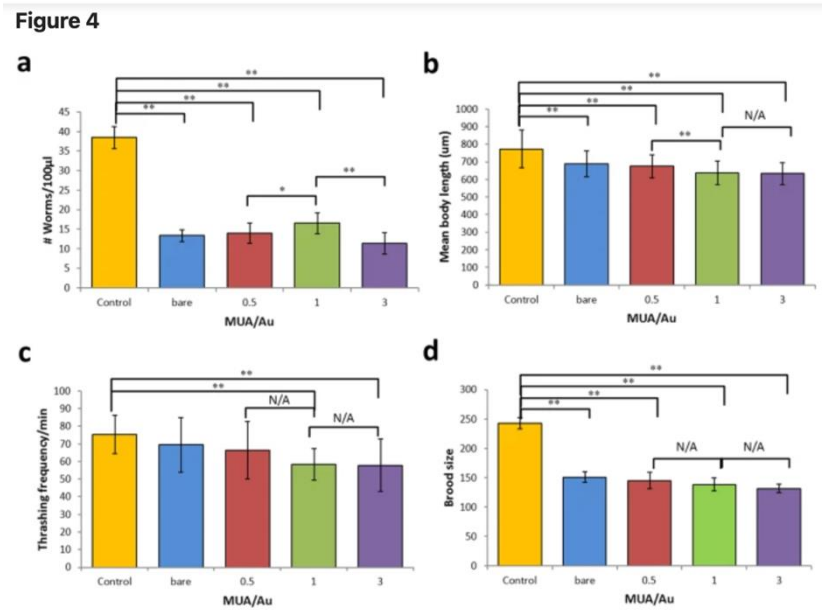
	SY5Y cells was recovered by Bcas gold nanoparticles; further investigated with staining of Congo red and no amyloid plaque formation was observed – so NPs worked. - Increasing AB dose to 600fM increased the AchE and GLT levels which are associated with Alzheimer's - Amyloid proteins interact with cell membrane to induce cytotoxicity and ROS production (Toxicity is determined by this) - Bcas AuNPs binded with AB to eliminate them and decrease the AD-like symptoms
Research Question/Problem/ Need	How can we eliminate the toxicity of amyloid-beta (AB) using gold nanoparticles?
Important Figures	 Figure 7. Shows the therapeutic potential of gold nanoparticles.
VOCAB: (w/definition)	Amyloid fibrils: protein aggregates that lead to many diseases Plaques: key feature or biomarker of neurogenerative diseases – especially Alzheimer's. Amyloid diseases: diseases when the protein amyloid builds up in the organs Oligomers: unstable structures which are made of a few repeating units derived from monomers Protofibrils: aggregates of amyloid-B (AB) protein Proteolysis: breaking down proteins into smaller amino acids Chaperone proteins: involved in preventing protein aggregation and misfolding Fibrillization: formation of threadlike structures Affinity: liking to something Xenobiotics: substances that are foreign to an organism

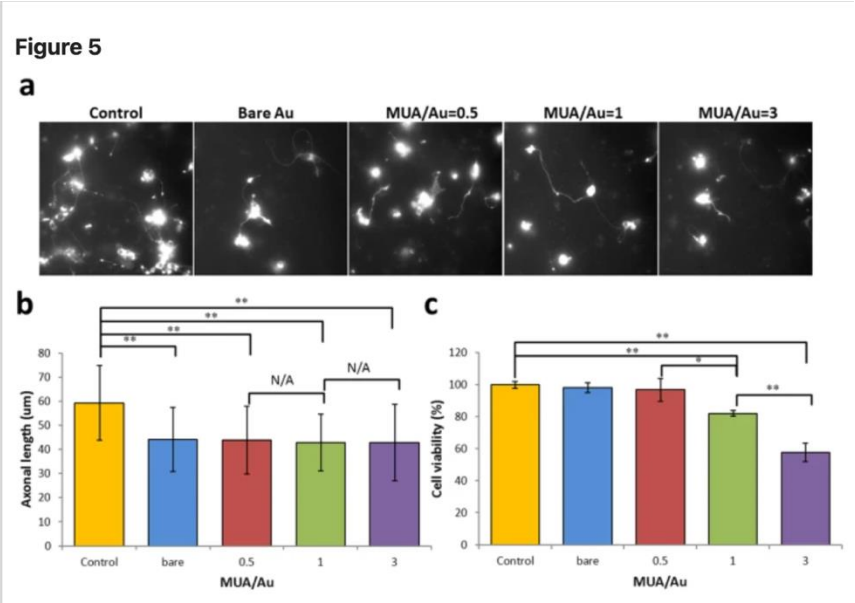
Cited references to follow up on	Sakono, M. & Zako, T. Amyloid oligomers: formation and toxicity of Aβ oligomers. *FEBS J.* **277**, 1348–1358 (2010).
Follow up Questions	How does the fact that zebrafish larvae develop cognitive and learning functions factor into this study as a whole? Would the study and results have been more effective and accurate if performed on a model organism which has advanced cognitive capacity? Would the results alter or be different when the AB and BCasAuNps are measured?

Article #9 Notes: Toxic Effects of Size-tunable Gold Nanoparticles on Caenorhabditis elegans Development and Gene Regulation

Article notes should be on separate sheets

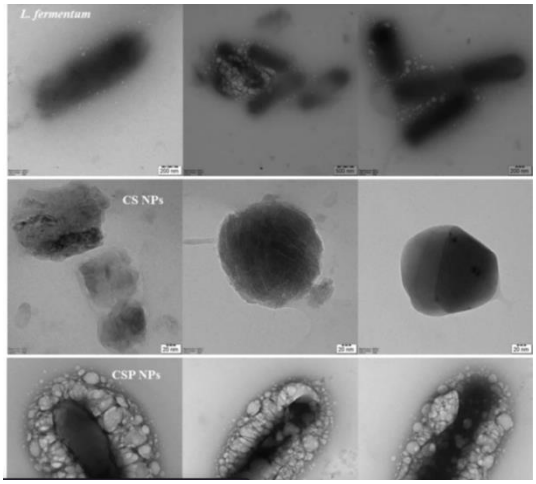
Source Title	Toxic Effects of Size-tunable Gold Nanoparticles on Caenorhabditis elegans Development and Gene Regulation
Source citation (APA Format)	Hu, C.-C., Wu, G.-H., Lai, S.-F., Muthaiyan Shanmugam, M., Hwu, Y., Wagner, O. I., & Yen, T.-J. (2018). Toxic Effects of Size-tunable Gold Nanoparticles on Caenorhabditis elegans Development and Gene Regulation. *Scientific Reports*, *8*(1). https://doi.org/10.1038/s41598-018-33585-7
Original URL	https://www.nature.com/articles/s41598-018-33585-7
Source type	Journal
Keywords	Gold nanoparticles, locomotion, neuron, nanotoxicity
#Tags	#C. elegans #nanoparticles #nanotoxicity
Summary of key points + notes (include methodology)	Background: - Nanoparticles are known for their size-dependent optical and electrical properties - nanoparticles are harmful to soil and water - AuNP's less than 2nm are used for bioimaging while other sizes pose an ecological risk - Changes in C.elegans locomotion behavioral assays can indicate neurological dysfunction - Toxicology: factors of body length, locomotion, reproduction and brood size - Conditions: exposure time, surface modification, particle size, nanoparticle concentration Key Points + methodology: - Au NPs are coated with 11-mercaptoundecanoic acid (MUA) to control particle size by x-ray irradiation (MUA has high affinity to gold nanoparticles) - Bare AU and MUA-Au NPs were observed in worms

	- Various modifications of the surface of nanoparticles leads to different cytotoxicities - Worm population was decreased significantly, reduction of worm growth, worm fertility - Looked at neuron cells before and after exposure to gold nanoparticles and concluded that axon growth was reduced - Increasing the MUA: Au ratio has a connection to the decreasing survival rate of neurons - Smaller particles are more capable of triggering oxidative stress on other cells - DNA microarray assays were done to see how the genes expressed were related to the study and nano particle exposure - For instance, the loss of acdh-1 can shorten lifespan, and this is related to the decrease in population size at Au NP exposure - Changes in gene expression is overall reflected in the phenotypic changes of C.elegans
Research Question/Problem/ Need	How does MUA coated gold nanoparticles impact the gene expression, toxicology and neuron development of C.elegans?
Important Figures	 Figure 4. Displays four behavioral assays. (A) Worm population (B) Mean body length (C) Locomotion (D) Reproduction. The study compares the effects of gold nanoparticles with the various ratios of MUA.

	 Figure 5. (A) uptake of gold nanoparticles for all experimental groups. (B) axonal length of neurons (C) cell viability for neurons
VOCAB: (w/definition)	Monodispersity: all the nanoparticles are the same size Morphogenesis: process that causes the shaping of an organism Confocal: having a common focus
Cited references to follow up on	Kim, S. & Ryu, D. Y. Silver nanoparticle-induced oxidative stress, genotoxicity and apoptosis in cultured cells and animal tissues. *J Appl Toxicol* **33**, 78–89 (2013). Hunt, P. R. The C. elegans Model in Toxicity Testing. *J. Appl. Toxicol.* **37**, 50–59 (2017). Moon, J., Kwak, J. I., Kim, S. W. & An, Y. J. Multigenerational Effects of Gold Nanoparticles in Caenorhabditis elegans: Continuous Versus Intermittent Exposures. *Environ. Pollut.* **220**, 46–52 (2017).
Follow up Questions	How do environmental conditions affect Au nanoparticles? What different surface modifications for the nanoparticles should we make to increase and decrease toxicity levels? If a similar study was done on other metallic and non-metallic nanoparticles of the same size, how would the results be changed? Is there a connection?

Article #10 Notes: Chitosan-coated probiotic nanoparticles mitigate acrylamide-induced toxicity in the *Drosophila* model

Source Title	Chitosan-coated probiotic nanoparticles mitigate acrylamide-induced toxicity in the *Drosophila* model
Source citation (APA Format)	Senthil, S. S., & Mohideen, S. S. (2024). Chitosan-coated probiotic nanoparticles mitigate acrylamide-induced toxicity in the drosophila model. *Scientific Reports*, *14*(1). https://doi.org/10.1038/s41598-024-72200-w
Original URL	https://www.nature.com/articles/s41598-024-72200-w
Source type	Journal
Keywords	Gut microbes, probiotics, nanoparticles, drosophila, pathogens, gut health, inflammation, treatment
#Tags	#nanoparticles #nanotoxicity
Summary of key points + notes (include methodology)	Background: - Nano-delivery systems created with biocompatible materials to manipulate the chemical and biological properties of compounds such as nutritional supplements - Probiotics are microbes that regulate gut bacteria - Some bacteria such as Bifidobacterium can interact and increase the beneficial bacteria by helping restore gut bacteria form dysbiosis - ACR- acrylamide—toxin that is harmful - L. fermentum – probiotic load Key Points + Methodology: - CS NPs with L.fermentum probiotics increased the particle size to 565nm - Orally put in fruit fly model to test against food-borne toxins like ACR - ACR induced flies displayed reduced larval crawling, low survival rates - ROS intensity levels increase due to oxidative stress and activation of antioxidant processes - Ovaries for female drosophila was used to test the mitochondrial membrane

	potential after ACR and CSPA - Mitochondrial depolarization (MD) caused by role of ACR in the eggs - CSPA treatment protects against ACR induced depolarization also cell death apoptosis - Importance of protecting the gastrointestinal system from pathogens and toxins such as ACR from dangerous foods - Chitosan- biopolymer – boost probiotic supplements, make gut healthy - Probiotic stain and its metabolite influence the dTOR pathways and target the nutrient development processes - CSPA treatment showed no toxicity in the model organism - Prevent inflammation and translocation of toxins into the circulatory system – maintaining healthy guts - Prepared with .5% chitosan and 8 log CFU/ml F fermentum probiotics
Research Question/Problem/ Need	How effective is the use of chitosan-coated probiotic nanoparticles against ACR-induced toxicity in the Drosophila?
Important Figures	 Figure 1. Imaging of gold nanoparticles
VOCAB: (w/definition)	Viability: ability to work successfully Nanoencapsulation: coating substances with a different material to create a nano capsule Polydispersity: particle size distribution Depolarization: loss of charge due to change in permeability or sodium ions
Cited references to follow up on	Zhang, T. *et al.* Cytoprotection of probiotics by nanoencapsulation for advanced functions. *Trends Food Sci. Technol.* **142**, 104227 (2023).

	Matoso, V., Bargi-Souza, P., Ivanski, F., Romano, M. A. & Romano, R. M. Acrylamide: A review about its toxic effects in the light of developmental origin of health and disease (DOHaD) concept. *Food Chem.* **283**, 422–430. https://doi.org/10.1016/j.foodchem.2019.01.054 (2019).
Follow up Questions	Could Chitosan be replaced with any other biopolymer and have the same results? What is the significance of using gold nanoparticles outside the biomedical areas? Can some nanoparticles decrease toxicity levels without binding?

Article #11 Notes: Liposomal Curcumin for Treatment of Diseases

Article notes should be on separate sheets

Source Title	Liposomal Curcumin for Treatment of Diseases
Source citation (APA Format)	Kurzrock, R., Li, L., Mehta, K., Aggarwal, B. B., & Helson, L. (2018). *Liposomal Curcumin for Treatment of Diseases* (Patent No. 20180318217). U.S. Patent and Trademark Office. https://www.freepatentsonline.com/y2018/0318217.html
Original URL	https://patents.google.com/patent/US20180161298A1/en?q=(autophagy+in+cancer)&oq=autophagy+in+cancer
Source type	Patent
Keywords	Curcumin, Liposomes, Cancer, disease, treatment, neurodegenerative disease, drug delivery
#Tags	#cancer #patent
Summary of key points + notes (include methodology)	Background: - Curcumin has antioxidant and anti-inflammatory properties - Suppress growth of certain cancers but depends on a lot of variables such as type; sometimes it induces apoptosis in certain cancers but other times it

	inhibits chemotherapy induced apoptosis of the cancer cells Invention: - Meant for efficient loading of curcumin into model by using liposomes - Administered dose of 0.01 mg/kg of the person's body weight to a maximum of 500mg/kg of their body weight - Providing patient with a good amount of curcuminoid: PEGylated-liposome ratio that will be enough to load curcumin into the liposome for treatment of malignant, non-malignant, autoimmune and auto-inflammatory diseases - Treating a parasitic infection by encountering the parasite with a good amount of the curcuminoid: liposome complex that is enough to treat the infections - Curcuminoids must be natural or synthetic - This ratio of the complex can also be used to treat non-human animals such as dogs, cats, hamsters - Treating humans with iron overload or hemochromatosis with the liposome curcuminoids complex - Liposomes are vesicles made of phospholipids - The delivery of curcumin through liposomes prevents and protects the curcumin from being absorbed into the cells - Proliferation and survival assays for pancreatic cells - Different methods on different variables and cancer testing - Can have an impact on neurodegenerative diseases such as Parkinson's, Alzheimer's, Huntington's, ALS and more - The inhibitory effects of the liposomal curcumin are shown to be irreversible
Research Question/Problem/ Need	What are the methods of delivery of Curcumin using liposomes for treatment of various diseases and what are the effects?

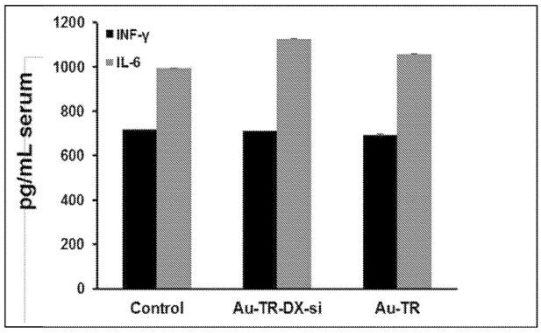
Important Figures	Inhibitory Concentration of Free vs. Liposomal Curcumin MTT Assay (72 hours incubation) Name of Cells / IC_{50} of free curcumin / IC_{50} of liposomal curcumin / IC_{90} of free curcumin / IC_{90} of liposomal curcumin BXPC-3: 2 µg/ml; 2 µg/ml; 5 µg/ml; 5 µg/ml 5.4 µM; 5.4 µM; 13.5 µM; 13.5 µM CAPAN-1: 2 µg/ml; 0.75 µg/ml; 5 µg/ml; 2.5 µg/ml 5.4 µM; 2 µM; 13.5 µM; 6.75 µM CAPAN-2: 17 µg/ml; 14 µg/ml; 35 µg/ml; 35 µg/ml 46 µM; 37.8 µM; 94.5 µM; 94.5 µM HS766-T: 2.6 µg/ml; 2.5 µg/ml; 8 µg/ml; 9 µg/ml 7 µM; 6.75 µM; 21.6 µM; 24 µM ASPC-1: 4 µg/ml; 4 µg/ml; 10 µg/ml; 10 µg/ml 10.8 µM; 10.8 µM; 27 µM; 27 µM Figure 1. MTT assay with 72 hours of incubation
VOCAB: (w/definition)	Liposomes: small vesicles that are used to deliver microscopic substances Curcuminoid: natural compounds derived from the family of Turmeric; very beneficial to health Hydrophobicity: physical property that describes its repellence to water
Cited references to follow up on	KM Nelson, JL Dahlin, J Bisson, J Graham, GF Pauli, MA Walters. "The Essential Medicinal Chemistry of Curcumin." Journal of Medicinal Chemistry, Vol. 60, 2017, pages 1620-1637. (Year: 2017) O Oransky. Retraction Watch. retractionwatch.com/2016/02/22/journal-retracts-7-papers-by-md-anderson-researcher-long-under-investigation/ accessed 17 July 2019, originally published 22 February 2016, pages 1-11. (Year: 2016)
Follow up Questions	What effects does curcumin have on toxicity? Is there any prominent toxicity build up before the treatment, and how does it change after exposure to curcumin? Since the results are irreversible, how does that factor into the scenarios where the curcumin treatment makes the disease worse?

Article #12 Notes: Gold nanoparticle based formulation for use in cancer therapy

Article notes should be on separate sheets

Source Title	Gold nanoparticle based formulation for use in cancer therapy

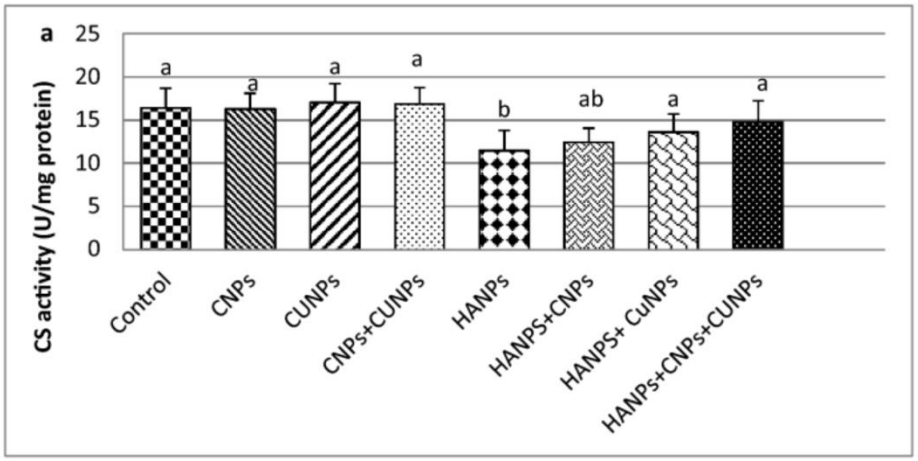
Source citation (APA Format)	Kotcherlakota, R., Mukherjee, S., Patra, C. R., & Gopal, V. (2020, October 20). *Gold nanoparticle based formulation for use in cancer therapy*. (Patent No. 10806715). U.S. Patent and Trademark Office. https://www.freepatentsonline.com/10806715.html
Original URL	https://www.freepatentsonline.com/10806715.html
Source type	Patent
Keywords	Cancer, nanoformulation, gold nanoparticles, TRAF, doxorubin, siRNA
#Tags	#cancer #nanoparticles
Summary of key points + notes (include methodology)	Summary + Background: - Combining gold nanoparticles with bi-functional fusion proteins TRAF© for drug delivery of anticancer and nucleic acids treatment to cure HER2+ cancers - Drug delivery system: nanoparticles + TRAF + doxorubin + siRNA - TRAF protein has the ability to target HER2+ receptors that are overexpressed in ovarian cancer cells - System found to be stable as there was accumulation of gold nanoparticles in tumors - Anticancer drugs disadvantages include toxic effects in other organs, less bioavailability, development of drug resistance - Tumors proliferate very quickly by overexpressing the growth receptors - Size of the nanoparticles ranged from 10-100 nm - Significance: dosage of treatment and therapeutic drugs can be decreased and still have long term prolonged activity - Synergistic effects in cancer cells which control the tumors - This formulation is non-immunogenic in mice Combination: AuNP + protein + anticancer drug +nucleic acid Methodology: - Combinatorial approach - SK-OV-3 xenograft model on nude mice was done to see the tumor suppression activity - The Au NPs new formulation has the potential to be used universally for non-invasive treatment of HER2+ cancer - Adding and incubating the compound

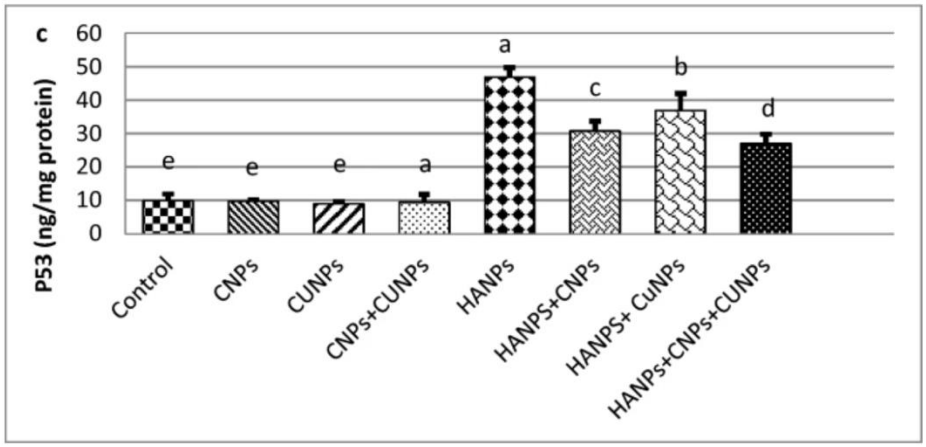
	- Transmission electron microscopy – revealed the increase of size of nanoparticles after combined with TR, DX, si - XRD analysis to find the structure of nanoparticles – revealed that the structure was the same before and after – so no difference after we added proteins and drug molecules - HER2 Receptor Expression analysis: western blotting using antibodies; indicated high levels which might contribute to the severity of cancers. This helped the researchers choose what cells and what types of cells to target the nanoparticles Preparation of gold nanoparticles: - Sodium borohydride reduction method: 10^-2(M) tretrachloroauric solution + 100ml millipore water + 50ml of 0.05 mg/ml sodiu borohydride solution - Stiffing overnight
Research Question/Problem/ Need	How does the nanoformulation made of gold nanoparticles, TRAF protein, doxorubin drug and siRNA affect HER2+ cancers?
Important Figures	 Fig. 4 Figure 1. Shows how different gold nanoparticles were impacting the concentrations of the serum through testing two different drugs.
VOCAB: (w/definition)	Bioavailability: extent to which a drug becomes completely available to the body via circulation Dimerizes: joining 2 similar molecular compounds by bonds Nanoformulation: combining drugs with nanotech to increase therapeutic efficacy Amplicon: a piece of DNA or RNA that can be artificially made from amplification or replication
Cited references to follow up on	Daniel et al., “Gold Nanoparticles: Assembly, Supramolecular Chemistry, Quantum-Size-Related Properties, and Applications toward Biology,

	Catalysis, and Nanotechnology", Chem. Rev., vol. 104, 2004, pp. 293-346. Paciotti et al., "Colloidal Gold Nanoparticles: A Novel Nanoparticle Platform for Developing Multifunctional Tumor-Targeted Drug Delivery Vectors", Drug Development Research, vol. 67, 2006, pp. 47-54.
Follow up Questions	Can we use this same therapeutic approach for other diseases? Can antioxidants be added to the mix? How will that affect the compound and affect cancers?

Article #13 Notes: The protective effects of chitosan and curcumin nanoparticles against the hydroxyapatite nanoparticles–induced neurotoxicity in rats

Source Title	The protective effects of chitosan and curcumin nanoparticles against hydroxyapatite nanoparticles=induced neurotoxicity in rats
Source citation (APA Format)	Gihan Mahmoud Eldeeb, Yousef, M. I., Helmy, Y. M., Hebatallah Mohammed Aboudeya, Mahmoud, S. A., & Kamel, M. A. (2024). The protective effects of chitosan and curcumin nanoparticles against the hydroxyapatite nanoparticles-induced neurotoxicity in rats. *Scientific Reports*, *14*(1). https://doi.org/10.1038/s41598-024-70794-9
Original URL	http://ezproxy.wpi.edu/login?url=https://www.proquest.com/sciencejournals/scholarly-journals/protective-effects-chitosan-curcumin/docview/3102226456/sem-2?accountid=29120
Source type	Journal
Keywords	Curcumin, nanoparticles, hydroxyapatite, neuronal dysfunction
#Tags	#nanoparticles #curcumin
Summary of key points + notes (include methodology)	Background: - Hydroxyapatite is a natural substance of human bone and is used in the dental industry; hydroxyapatite nanoparticles (HANPs) were created for drug delivery, imaging and gene therapy

	- When NPs accumulate major organs, they may cause tissue damage and other biological reactions; the neurotoxic effects of HANPs have not been confirmed nor denied. - Curcumin and chitosan have protective properties due to being antioxidants; prepared CNPs and CUNPs to test against toxicity in rat's kidneys - The combination of CNPs and CUNPs with HANPs fixed the fluctuating levels of neurotransmitters and corrected them - Treatment with HANPs led to a decline in GPX, SOD, GST, CAT, GSH and TAC levels while the NO levels increased. However, combined treatment with Curcumin and chitosan showed opposite results like decreasing levels of NO - The combination of HANPs, CNPs, CUNPs improved the levels of TNF-a, IL-6, and p53 compared to the controls which are pro-inflammatory cytokines and a tumor suppressor gene. - Treatment with HANPs revealed the increasing amounts of damaged neurons, and neuronal degeneration. However, after combining the treatment with Cu and C revealed mild neuron degeneration - Neurotoxicity is connected to oxidative stress (indicator), mitochondrial and neuronal dysfunction, inflammation and neurological diseases
Research Question/Problem/ Need	What are the neurotoxic effects of HANPs in rats and how do CNPs and CUNPs counter the neurotoxicity induced by HANPs in the rats?
Important Figures	**Fig. 2**  The levels of CS (citrate synthase) activity vary with different combinations of nanoparticles.

	 The levels of P53 tumor suppressor vary with the different combinations of nanoparticles.
VOCAB: (w/definition)	Nephrotoxicity: kidneys are damaged by toxins or drugs Neurofibrillary degeneration: brain lesion that is a key feature of Alzheimer's Necrosis: irreversible death of cells
Cited references to follow up on	Cole, G. M., Teter, B. & Frautschy, S. A. Neuroprotective effects of curcumin. *Adv. Exp. Med. Biol.* **595**, 197–212 (2007)
Follow up Questions	How can the levels be altered when we change the type of nanoparticles? What is the difference between using HANPs and using a metallic nanoparticle for this study? Will it change the results?

Article #14 Notes: Curcumin-gold nanoformulation: Synthesis, characterizations and biomedical application

Source Title	Curcumin-gold nanoformulation: Synthesis, characterizations and biomedical application
Source citation (APA Format)	Amini, S. M., Emami, T., Rashidi, M., & Zarrinnahad, H. (2024). Curcumin-gold nanoformulation: Synthesis, characterizations and biomedical application. *Food Bioscience*, *57*. https://doi.org/https://doi.org/10.1016/j.fbio.2023.103446

Original URL	https://www.sciencedirect.com/science/article/pii/S2212429223010970
Source type	Journal
Keywords	Gold nanoparticles, curcumin, biocompatibility, neurodegenerative diseases, cancer, cardiovascular diseases
#Tags	#curcumin #nanoparticles
Summary of key points + notes (include methodology)	- Metal nanoparticles are most common in medicine; gold is most common for therapeutic treatment but making them with other dangerous chemicals can make it nonstable - Cur, a phytochemical: delay aging and can be used instead of reducing and capping agents - Curcumin can prevent neural damage, help inflammation and cross the BBB, protective effects on cells in CNS like hippocampus, cortical and spinal cord - Amyloids have neurotoxic effects and aggregation leads to neurodegenerative disorders developing - Cur has small antimicrobial properties - ROS (reactive oxygen species) and RNS are being produced naturally as part of metabolism; antioxidants such as cur or Cur@AuNPs have high antioxidant properties Methodology of making metal nanoparticles: - Can use chemical compounds as reducing or capping agents or plant extracts - Cur is used as an ion-reducing agent - Cur is added to HauCl4 aq. Medium at alkaline PH or hot temp. (reduces Au ions) with sodium hydroxide - When we increase temp, OH group and the keto group of Cur provide Au 3+ with electrons due to being exposed to oxidation (this increases solubility of Cur) - Concentration of curcumin affect the size because as we increase concentration, particle size decreases - Varying HauCl4: Cur ratio affects shape of particles - Surfactants such as PEG (polyethylene glycol) can be added to stabilize nanoparticles - To increase solubility, compounds like hyaluronic acid can be added - To check and characterize the synthesized particles: Spectroscopy, TEM

	techniques are done to check size, formation etc.
Research Question/Problem/ Need	How can gold nanoparticles be synthesized with Curcumin and what are the characteristics, impacts and application in the real world?
Important Figures	N/A
VOCAB: (w/definition)	Zeta potential: surface charge of particles; necessary for testing stability of nanoparticles
Cited references to follow up on	W.-H. Lee, C.-Y. Loo, M. Bebawy, F. Luk, R.S. Mason, R. Rohanizadeh Curcumin and its derivatives: Their application in neuropharmacology and neuroscience in the 21st century Current Neuropharmacology, 11 (4) (2013), pp. 338-378 A. Mohammadi, A.H. Colagar, A. Khorshidian, S.M. Amini The Functional roles of curcumin on astrocytes in neurodegenerative diseases Neuroimmunomodulation (2021), pp. 1-11 E. Shaabani, S.M. Amini, S. Kharrazi, R. Tajerian Curcumin coated gold nanoparticles: Synthesis, characterization, cytotoxicity, antioxidant activity and its comparison with citrate coated gold nanoparticles Nanomedicine Journal, 4 (2) (2017), pp. 115-125
Follow up Questions	Is there no toxicity when combining curcumin with gold nanoparticles? Or is it just improved?

Article #15 Notes: Modeling Neurodegenerative Diseases in Caenorhabditis elegans

Source Title	Modeling Neurodegenerative Diseases in Caenorhabditis elegans
Source citation (APA Format)	Li, J. & Le, W. Modeling Neurodegenerative Diseases in Caenorhabditis elegans. *Exp. Neurol.* **250**, 94–103 (2013).
Original URL	https://www.sciencedirect.com/science/article/abs/pii/S0014488613002926?via%3Dihub

Source type	Part of a book
Keywords	AB, neurons, neurodegenerative, Huntington's, AD
#Tags	#C.elegans
Summary of key points + notes (include methodology)	Background: - As age and longevity increases, neurodegenerative diseases increase due to feature of accumulation of protein aggregation - C.elegans has lifecycle of 3.5 days and 3 weeks at 20 Celsius. - 302 neurons in the worm and 42% of human disease genes are in the worm Alzheimer's disease: - Majorly caused by neurofibrillary tangles and AB peptide which is made of 40-42 amino acids - AB contains the gene tau but mutations to the gene does not cause AD but other neurodegenerative diseases - Studies done in C.elegans shows thar having a chaperone protein as a binder can protect against AB toxicity. - Decreased insulin or an insulin growth factor can also decrease AB toxicity - Coffee extract, copper and traditional chinese medicine have proven to have protective effects against AB toxicity - Another indicator is the aggregation of tau - Presynaptic defect was observed since worms are uncoordinated and this leads to neurodegeneration due to tau aggregation - 60 genes in the worm were found to enhance the tau-induced toxicit and defects PD: - Caused by loss of dopamine neurons - Indicators is lewy bodies (A-synuclein, neurofilament and ubiquitin) - A-synculein belongs to the central nervous system and regulates the membrane and neurotransmitter release - Worms were overexpressed with A-synculein in dopamine neurons - Dopamine neurodegeneration was observed – toxic Huntington's disease: - Caused by CAG triplet expansion in the N-terminal of the Huntington proteins - Pathogenic protein is misfolded and so leads to neural dysfunction and

	aggregation - Pan-neural worm polyQ model with the ref-1 promoter showed polyQ length-dependent aggregation and also signs of neurotoxicity - Forward genetics and reverse genetic applications on C.elegans is available
Research Question/Problem/ Need	What causes neurodegenerative disorders and how are they exemplified in C.elegans?
Important Figures	none
VOCAB: (w/definition)	Endogenous: having an internal cause Proteosomal: complex of enzymes that degrade unwanted proteins Panneural: relating to all neurons Commissures: nerve tissue connecting hemispheres in brain Ameliorate: make better
Cited references to follow up on	P.E. Ash, Y.J. Zhang, C.M. Roberts, T. Saldi, H. Hutter, E. Buratti, L. Petrucelli, C.D. Link Neurotoxic effects of TDP-43 overexpression in *C. elegans* Hum. Mol. Genet., 19 (2010), pp. 3206-3218
Follow up Questions	Are there any natural substances tested that can decrease the neural toxicity in C.elegans? What are they? Can they be modified to heal neurons and prevent them from death?

Article #16 Notes: Curcumin coated gold nanoparticles: synthesis, characterization, antioxidant activity and its comparison with citrate coated gold nanoparticles

Source Title	Curcumin coated gold nanoparticles: synthesis, characterization, antioxidant activity and its comparison with citrate gold nanoparticles
Source citation (APA Format)	Shaabani, E., Amini, S. M., Kharrazi, S., & Tajerian, R. (2017). Curcumin coated gold nanoparticles: synthesis, characterization, cytotoxicity, antioxidant activity and its comparison with citrate coated gold

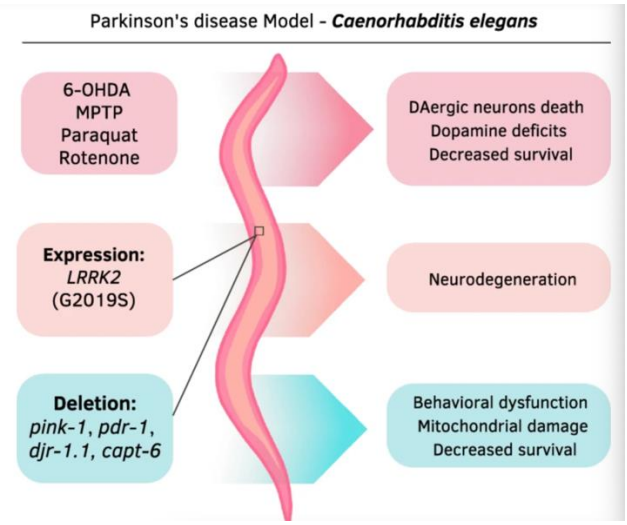
	nanoparticles. *Nanomedicine Journal*, *4*(2), 115–125. https://doi.org/10.22038/nmj.2017.8413
Original URL	https://nmj.mums.ac.ir/article_8413.html
Source type	Research paper
Keywords	Antioxidant activity, curcumin, gold nanoparticles, green synthesis
#Tags	#curcumin #methodology
Summary of key points + notes (include methodology)	Summary: Properties: - Tunable surface plasmon resonance - Biocompatibility - High surface reactivity - Oxidation resistance - When chemicals are used for metal ion reduction, and this can induce toxicity and can also cause environmental pollution - Compared with chemically synthesized citrate coated gold nanoparticles in this study to investigate toxicity Methodology: 1. Materials: Tetra Chloroauric (III) acid trihydrate, Curcumin, Dimethyl sulfoxide (DMSO), Potassium carbonate 2. 120 µl of 20 mM curcumin in DMSO is combined with 7ml of DI water 3. pH was set to 9-10 according to drop by drop adding of Potassium carbonate 150 mM 4. Stir for 5 mins 5. 2.5 ml solution of Tetra Chloroauric (III) acid trihydrate (4 mM in water) was added drop by drop 6. Volume should be set to 10ml with addition of DI water if needed 7. 4hrs rigorous stirring 8. Aged for 3 days to complete the reaction with time 9. To remove all excess curcumin, centrifuge filter tubes were used at 4000 rpm for 4 min 10. Centrifugation process was repeated 4 times 11. Check UV-Vis absorbance spectra to confirm no excess curcumin UV-Vis absorbance Spectroscopy: study the average particle size and size

	stability Dynamic Light Scattering measurements (DLS): average particle size, size distribution of particle, zeta potential Transmission Electron microscopy: size and size distribution of particles Average size: 21.7 ± 5.7 nm Curcumin: usage is limited due to low water solubility and low bioavailability - To increase bioavailability, we conjugate curcumin to gold nanoparticles - In aqueous media, we can increase its activity, half-life, and stability
Research Question/Problem/ Need	How are curcumin coated gold nanoparticles created?
Important Figures	None
VOCAB: (w/definition)	Biocompatibility: the ability of a material to interact with a living system without producing an adverse effect Triplicate: consisting of 3 identical parts Bioavailability: the extent a substance or drug becomes completely available to its intended biological destination
Cited references to follow up on	S.C. Gupta, S. Patchva, W. Koh, B.B. Aggarwal Discovery of curcumin, a component of golden spice, and its miraculous biological activities Clinical and Experimental Pharmacology and Physiology, 39 (3) (2012), pp. 283-299
Follow up Questions	Does curcumin's bioavailability increase if it is exposed to gold nanoparticles in the worm but isn't exactly coated? Does increasing concentrations of curcumin have an impact on gold nanoparticles? Are there any toxic effects to be expected?

Article #17 Notes: Exploring *Caenorhabditis elegans* as Parkinson's Disease Model: Neurotoxins and Genetic Implications

Source Title	Exploring *Caenorhabditis elegans* as Parkinson's Disease Model: Neurotoxins and Genetic Implications
Source citation (APA Format)	da Silva, L. P., da Cruz Guedes, E., Fernandes, I. C., Pedroza, L. A., da Silva Pereira, G. J., & Gubert, P. (2024). Exploring Caenorhabditis elegans as Parkinson's Disease Model: Neurotoxins and Genetic Implications. *Neurotoxicity Research*, *42*(1). https://doi.org/10.1007/s12640-024-00686-3
Original URL	https://link.springer.com/article/10.1007/s12640-024-00686-3
Source type	Journal
Keywords	Parkinson's, Behavioral assays, Neurotoxins, C.elegans
#Tags	#C.elegans #methodology #parkinsons
Summary of key points + notes (include methodology)	Background: - PD affects Substantia nigra (SN) and this causes motor symptoms - Main symptoms: tremor at rest, slowness, instability, stiffness, sleep disorders, dementia, anxiety, depression - Neuronal damage is indicated by basal slowing response, ethanol avoidance, swimming behavior, Swimming-induced paralysis - It takes 3 days to grow the worms from egg to adult nematode at temp of 20 Celsius - Though there are many differences between human and c.elegans nervous system, the worm uses neurotransmitters for synaptic communication; for example, serotonin and dopamine - Dopamine receptors can affect lifespan, body-size, movement, fast body movement, reproductive lifespan and development in the worm - Connections between specific neurons and behaviors: crawling, swimming, chemotaxis, mating and touch response Nematode culture: Petri dishes containing nematode growth medium (NGM) agar and E. coli bacteria for the food source Assays: - Basal Slowing Response Assay: body bending; if the worms have DA neurodegeneration, they are unable to decrease the bending frequency in response to food. Notice the difference in body bending over a time of 20

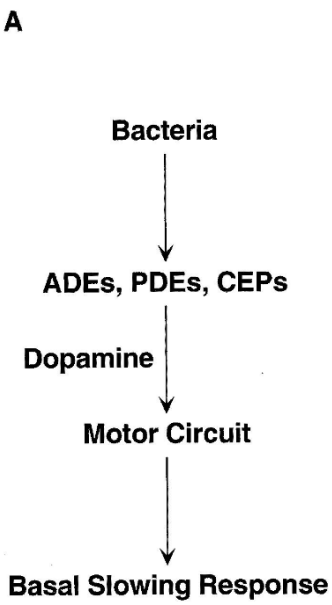
	seconds between presence and absence of food. Control: rate of bending should be reduced to allow worms to feed when approaching eating time - Chemotaxis or Ethanol Avoidance Assay: Effective because lots of PD patients have olfactory dysfunction. Ethanol avoidance index: (difference in number of nematodes in control and number of nematodes with ethanol)/total worms - Swimming Behavior Assay: to test toxicity caused by a-synuclein; worms are placed in plates containing M9 buffer. The swimming movement is counted for 30 mins – should notice decreased swimming activity 6-OHDA: - Enters DA neurons and accumulates in mitochondria—leads to degeneration - Exhibits decreased swimming movement and change in chemotaxis behaviors - Decreased survival rate - Incubated in 96-well plates with 6-OHDA for 1 hr. - Worms are moved to NGM plates with food source, after 24, 48, or 72 hrs. Paraquat: - Herbicide, worsens oxidative stress Rotenone: - Insecticide inhibits mitochondrial complex 1. - Decrease in DA neurons; decreased average speed, body bends, decreased swimming movements, decreased survival - Leads to mitochondrial dysfunction
Research Question/Problem/ Need	How do different neurotoxins affect behavioral types of C.elegans?

Important Figures	 Figure 1. Factors of a Parkinson's disease model
VOCAB: (w/definition)	None
Cited references to follow up on	Cooper JF, Van Raamsdonk JM (2018) Modeling Parkinson's disease in *C. elegans*. J Parkinsons Dis 8:17–32. https://doi.org/10.3233/JPD-171258 Liang JJH, McKinnon IA, Rankin CH (2020) The contribution of *C. elegans* neurogenetics to understanding neurodegenerative diseases. J Neurogenet 34:527–548. https://doi.org/10.1080/01677063.2020.1803302
Follow up Questions	Which neurotoxin is best to test on C. elegans? What are the advantages of testing one over the other? Any health consequences for testing it in a lab?

Article #18 Notes: *C. elegans* Locomotory Rate Is Modulated by the Environment through a Dopaminergic Pathway and by Experience through a Serotonergic Pathway

Source Title	*C. elegans* Locomotory Rate Is Modulated by the Environment through a Dopaminergic Pathway and by Experience through a Serotonergic Pathway
Source citation (APA Format)	Sawin, E. R., Ranganathan, R., & Horvitz, H. R. (2000). C. elegans locomotory rate is modulated by the environment through a dopaminergic pathway and by experience through a serotonergic

	pathway. *Neuron*, *26*(3), 619–631. https://doi.org/10.1016/s0896-6273(00)81199-x
Original URL	https://pmc.ncbi.nlm.nih.gov/articles/PMC10960252/
Source type	Journal
Keywords	Plasticity, dopamine, serotonin
#Tags	#dopamine #locomotion #parkinson's #assays
Summary of key points + notes (include methodology)	- Behavioral plasticity includes the properties of neurons and synapses - The alteration is caused by neuromodulators such as dopamine - Parkinson's includes disruption of dopaminergic systems - Locomotion and egg laying involve dopaminergic signaling - Well-fed C.elegans L4, when washed free of bacteria and introduced to it later, move slower than when they are in an environment without bacteria - Slowing response to bacteria was enhanced when they are deprived of food for 30 mins - Basal slowing response requires dopamine ** refer to article for more information on mutations and dopamine signaling
Research Question/Problem/ Need	How does dopamine affect basal slowing response in C. Elegans?

Important Figures	 Figure 1. Model of Basal Slowing Response
VOCAB: (w/definition)	Cell-type ablations: biotech tool that involves removing cells in an organism Preincubation: incubating a cell before treatment Exogenous: growing on the outside
Cited references to follow up on	Avery, L. · Horvitz, H.R. **Effects of starvation and neuroactive drugs on feeding in *Caenorhabditis elegans*** *J. Exp. Zool.* 1990; **253**:263-270
Follow up Questions	Are there specific assay plates?

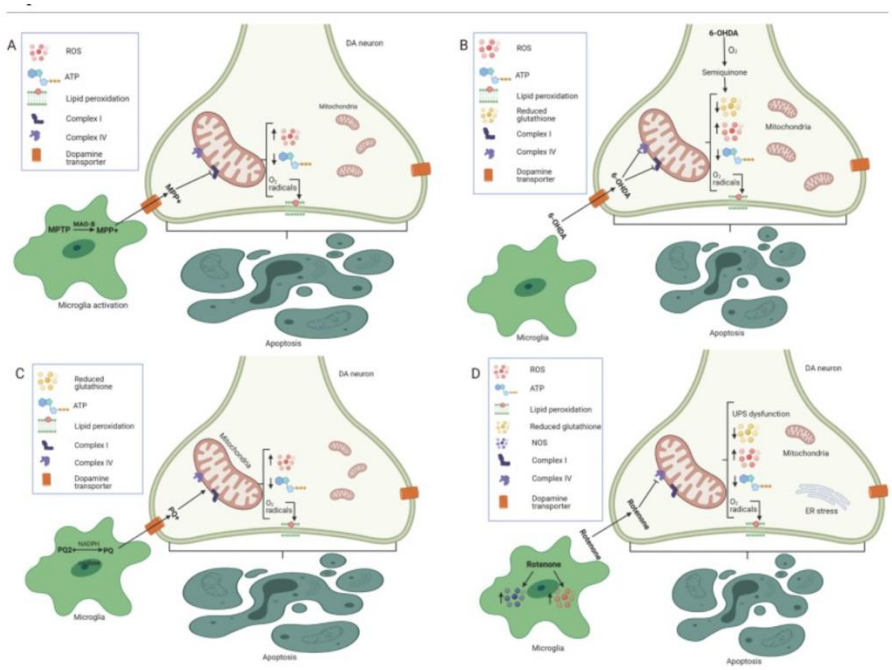
Article #19 Notes: 6-OHDA-induced dopaminergic neurodegeneration in *Caenorhabditis elegans* is promoted by the engulfment pathway and inhibited by the transthyretin-related protein TTR-33

Source Title	6-OHDA-induced dopaminergic neurodegeneration in *Caenorhabditis elegans* is promoted by the engulfment pathway and inhibited by the transthyretin-related protein TTR-33
Source citation (APA Format)	Offenburger, S.-L., Ho, X. Y., Tachie-Menson, T., Coakley, S., Hilliard, M. A., & Gartner, A. (2018). 6-OHDA-induced dopaminergic neurodegeneration in caenorhabditis elegans is promoted by the engulfment pathway and inhibited by the transthyretin-related protein TTR-33. *PLOS Genetics*, *14*(1). https://doi.org/10.1371/journal.pgen.1007125
Original URL	https://pmc.ncbi.nlm.nih.gov/articles/PMC5773127/
Source type	Journal
Keywords	6-OHDA, assay, inducing
#Tags	#6-OHDA #assay
Summary of key points + notes (include methodology)	- oxidative stress is caused by increase in ROS - death of dopaminergic neurons in substantia nigra of the midbrain is one of hallmark of PD - abnormal aggregation of a-synuclein proteins known as Lewy bodies - C.elegans hermaphrodites have 8 dopaminergic neurons - 6-OHDA is absorbed into dopamine neurons and causes oxidative stress by blocking complex 1 of respiratory chain; dopaminergic neurons die Methods: Strains were grown at 20 Celsius; Strains were bought from the CGC. 6-OHDA assays: - 1-10 adult worms were incubated to lay eggs in 70 µL M9 without food on a centrifuge at 20 degrees Celsius – 500rpm for 24-30 hours - 10 µL 200 mM ascorbic acid and 10 µL of the respective 6-OHDA **5x stock** concentration were prepared in H2O and added to 30 µL of L1-stage larvae in M9 - After 1 hr incubation at 20 Celsius and shaking at 500rpm, 150 µL M9 buffer - Animals were pipetted to ½ of the NGM plate containing a strip of OP50 on the other half - All other worms and eggs were removed from plate that were not exposed to 6-OHDA

	- Wait 72 hours for 20 Celsius Lifespan assays: - 50 L4 worms were picked and moved to new plates every day for 6 days and later to avoid mixing with young people - If animals don't move after being touched with a platinum pick, they are dead - Dead animals are removed every day Basal slowing assays: - NGM plates were prepared and half of them are seeded with HB101 before incubation at 37 degrees overnight - L4 larvae were picked separately on seeded plates - Next day, the well-fed worms are placed in 40 µL of M9 for 2 minutes to clean them from bacteria and picked to center of plate - 6 worms were put on a plate with and without bacteria - After 2 mins passed, count number of body bends in 5 consecutive 20s intervals - The experiment was performed twice on different days
Research Question/Problem/ Need	What methods were done to incubate 6-OHDA in the worms? What assays were performed to test the dopamine levels?
Important Figures	none
VOCAB: (w/definition)	none
Cited references to follow up on	Sulston J, Dew M, Brenner S. Dopaminergic neurons in the nematode Caenorhabditis elegans. J Comp Neurol. UNITED STATES; 1975;163: 215–226. doi: 10.1002/cne.901630207
Follow up Questions	What does 5x stock concentration entail? Is it a dilution process?

Article #20 Notes: Chemically induced models of Parkinson's disease

Source Title	Chemically induced models of Parkinson's disease
Source citation (APA Format)	Thirugnanam, T., & Santhakumar, K. (2022). Chemically induced models of Parkinson's disease. *Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology*, *252*, 109213. https://doi.org/https://doi.org/10.1016/j.cbpc.2021.109213
Original URL	https://www.sciencedirect.com/science/article/pii/S1532045621002404
Source type	Journal
Keywords	Neurotoxin, paraquat, 6-OHDA, rotenone, loss of DA neurons
#Tags	#neurotoxin #parkinson
Summary of key points + notes (include methodology)	Background: - Depletion of DA neurons - Symptoms of PD patients range from non-motor and motor such as mood swings, cognitive impairment, pain, sleep disturbance, low blood pressure, tremors, instable posture - Causes include risk factors such as age, genetic factors, environmental factors - Mutations such as *pink-1,* DJ-1, SNCA, *LRRK2, and* PRKN – oxidative stress - Pathologies include α-synuclein aggregation, mitochondrial dysfunction, apoptosis, neuroinflammation, reactive oxygen species (ROS) formation 6-OHDA: - Neurotoxin to induce Parkinson's features (hydroxylated form of dopamine) Treatment: 25mM for WT N2 Bristol nematode -- 48% decreased body bends; 45% decreased head thrashes; loss of DA neurons (More specific treatment options and results are specified in the journal) Paraquat: Herbicide with redox property and damages cells Treatment: 0.2, 0.4, 0.6, 0.8, 1.2, 1.6 mM for BZ555 nematodes – decreased

	mean speed, decreased body bends, irregular crawling, changes in body size, ATP depletion, loss in motor skills Rotenone: Pesticide that when ingested, symptoms are shown. Causes cell death by established neurotoxicity in DA neurons by generating ROS. Causes a-synuclein aggregation. 3–5 µM treatment – loss of DA neurons Tested neuro-toxin animal models to imitate PD features and symptoms
Research Question/Problem/ Need	How do specific neurotoxins affect various animal models and exhibit Parkinson's features?
Important Figures	 Figure 1. Representation of the major neurotoxins processes (A) MPTP, B) 6-OHDA, C) Paraquat and D) Rotenone which are all used to induce the Parkinson's symptoms in various animal model
VOCAB: (w/definition)	Transgenic: organism whose genome has been altered by another species DNA
Cited references to follow up on	D. Alvarez- Fischer, C. Henze, C. Strenzke, J. Westrich, B. Ferger, G.U. Höglinger, W.H. O ertel, A. Hartmann Characterization of the striatal 6-OHDA model of Parkinson's disease in wild-type and α-synuclein-deleted mice Exp. Neurol., 210 (2008), pp. 182-193

	M. Bisbal, M. Sanchez Neurotoxicity of the pesticide rotenone on neuronal polarization: a mechanistic approach Neural Regen. Res., 14 (2019), pp. 762-766
Follow up Questions	Does rotenone induce any behavioral phenotype changes in C.elegans? If so, what are they? Can we use assays to determine them?

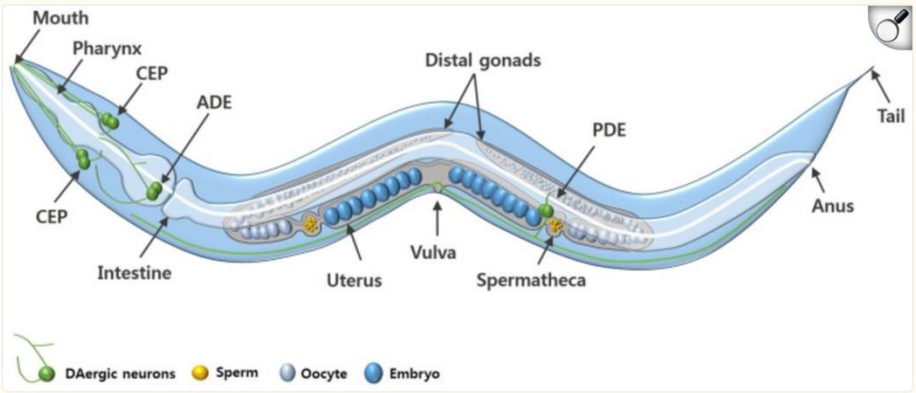
ASSAYS:
Basal Slowing: triggered by dopaminergic mechanosensory neurons which detect bacteria such as the food source

- Feeding behavior where locomotion rate depends on if C.elegans is in presence or absence of the bacterial lawn and food source
- Control: crawl slowly in the presence of food because they are stopping to eat
- Disruption of dopamine signaling prevent the nematode from slowing down in the presence of food – higher crawling speed
- Basal slowing ratio: (rate of movement absence of food – rate of movement in presence of food)/ rate in presence

Article #21 Notes: *Caenorhabditis elegans*: a model to investigate oxidative stress and metal dyshomeostasis in Parkinson's disease

Source Title	*Caenorhabditis elegans*: a model to investigate oxidative stress and metal dyshomeostasis in Parkinson's disease
Source citation (APA Format)	Chege, P. M., & McColl, G. (2014b). Caenorhabditis elegans: A model to investigate oxidative stress and metal dyshomeostasis in parkinson's disease. *Frontiers in Aging Neuroscience*, *6*. https://doi.org/10.3389/fnagi.2014.00089
Original URL	https://pmc.ncbi.nlm.nih.gov/articles/PMC4032941/#:~:text=This%20suggests%20that%20increased%20ROS,can%20further%20exacerbate%20PD%20progression.
Source type	Journal

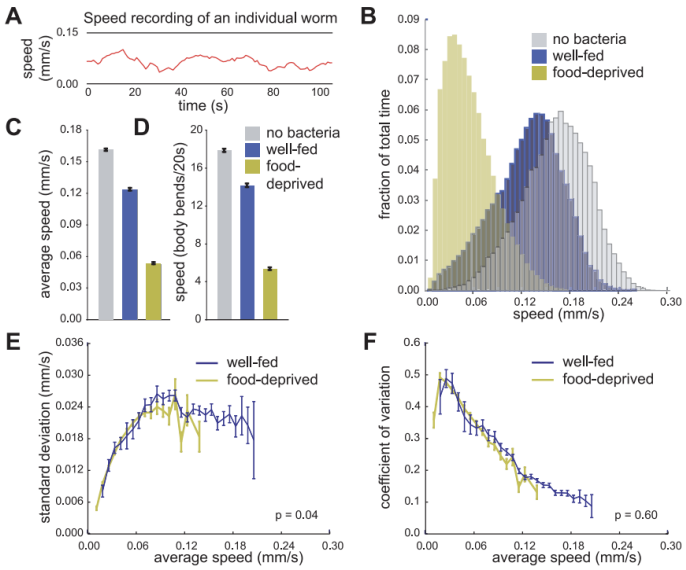
Keywords	Oxidative Stress, a-synuclein, Parkinsons, C.elegans, DAergic neurons
#Tags	#C.elegans #Parkinson's
Summary of key points + notes (include methodology)	- Severe motor impairment due to loss depletion of dopamine which is because of progresseive neurodegeneration of dopaminergic neurons in substantia nigra (region in brain which is part of the basal ganglia and is important for voluntary motor functions) - Current treatments focus on symptoms, don't stop neurodegeneration and loss efficacy over time - Another way of DA loss is thru Lewy bodies - Oxidative stress is major component to neuronal loss: from mitochondrial dysfunction, neuroinflammation, toxins - C.Elegans, 1mm in length, short life cycle - Adult lifespan for 3 weeks, 80% of C.elegans genes have human homolog - C.elegans are optically transparent, using fluorescent proteins which enable us to see the neurons locations - The motor symptoms of PD occur when around 50-70% of the nigral neurons are degenerated - DA is a very important neurotransmitter that controls motor - Other regions of brain are also affected which leads to nonmotor symptoms such as dementia, depression, cognitive impairment - Lewy bodies consist of a-synuclein proteins – cognitive functions, decrease in DA, regulates DA release - C.elegans consist of 8 total neurons: 6 DAergic and 2 PDE neurons - Loss of DAneurons – important for basal slowing response because DA is necessary for mechanosensation - Oxidative stress leads to cell damage because of the imbalance between toxic oxidant and antioxidant - ROS – superoxide and hydroxyl radical are the by-products of cell metabolism - ROS is important in signaling, and immune system to prevent microbes from infecting the cells - The by-products could potentially be toxic if the ROS levels are too high - Increased ROS levels directly cause neuron damage and indirectly lead to neurodegeneration of dopamine - DJ-1 and PINK1 are linked to early onset of PD

Research Question/Problem/ Need	What is the pathology of Parkinson's and how is it displayed in C.elegans?
Important Figures	Figure 1.  Figure 1. An Adult C. elegans anatomical features including the DAergic neurons of C. elegans. The green highlighted neurons are the DA neurons which include four cephalic (CEP)neurons, two anterior deirid (ADE) neurons and two posterior deirid (PDE) neurons.
VOCAB: (w/definition)	Homolog: homologous thing
Cited references to follow up on	Nass R., Hall D. H., Miller D. M., 3rd., Blakely R. D. (2002). Neurotoxin-induced degeneration of dopamine neurons in *Caenorhabditis elegans*. Proc. Natl. Acad. Sci. U.S.A. 99, 3264–3269 10.1073/pnas.042497999
Follow up Questions	Is testing oxidative stress enough for looking at levels of dopamine? How does locomotion directly connect?

Article #22 Notes: Dopamine Signaling Is Essential for Precise Rates of Locomotion by C. elegans

Source Title	Dopamine Signaling Is Essential for Precise Rates of Locomotion by C. elegans
Source citation (APA Format)	Omura, D. T., Clark, D. A., Samuel, A. D., & Horvitz, H. R. (2012). Dopamine signaling is essential for precise rates of locomotion by C. elegans. *PLoS ONE*, *7*(6). https://doi.org/10.1371/journal.pone.0038649

Original URL	https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0038649&type=printable
Source type	Journal
Keywords	Locomotion, dopamine, C.elegans, signaling
#Tags	#Parkinson's #assays # Data Analysis
Summary of key points + notes (include methodology)	- C. elegans locomotion is made up of dorsal-ventral muscular and cellular consequences of impaired DA signaling - Transitions between crawling and swimming - Mutants that lack DA move faster than wild-type on a bacterial lawn—Dopamine plays an important role in slowing response - For worms that lack DA, there were signs of high erratic rates of locomotion - Used locomotion tracking system - Examined avg speed of well fed and food-deprived animals on bacteria - Well-fed worms move at 76% while food deprived worms move at 32% of their locomotion rate in the absence of bacteria - Manual assay to count body bends – 79% and 30% respectively - Dopamine deficient mutants make large adjustments to their speed due to inconstant velocity and acceleration - The six neurons in the worms are known to control mechanosensory detection of food source - Suggests that the PDE neuron releases dopamine while worms are moving
Research Question/Problem/ Need	How is locomotion connected to dopamine signaling?

Important Figures	 Figure 1. Locomotion assay in wild-type C. elegans. (A) speed recording of an individual worm. (B) Frequency distributions of instantaneous speed recordings of animals well-fed on bacteria, food deprived, and off-bacteria. (D) Average speed measured by manually counting body bends over 20 secs intervals. (E) Standard deviation of and (F) coefficients of variation of speed measurements for overall worm tracks.
VOCAB: (w/definition)	None
Cited references to follow up on	Clark DA, Gabel CV, Lee TM, Samuel AD (2007) Short-term adaptation and temporal processing in the cryophilic response of Caenorhabditis elegans. J Neurophysiol 97: 1903–1910.
Follow up Questions	Did the software only record the data, or did it create the graphs? Was the locomotion and basal slowing response assay performed in the study the same? Was it done simultaneously and not separately?