Welcome to

STEMTALKS

INFORMAL COLLOQUIA | EXPERT INSIGHTS | PUBLIC UNDERSTANDING

HOSTED BY THE STEM ORIGINS FOUNDATION

- An informal forum for discussion of timely & relevant STEM Topics
- Based on expert technical insights of senior STEM professionals
- Presented in easily understood terms for Public Understanding
- Provided by the STEM Origins Foundation as a community service to LMWS
- Open Invitation to new Briefers & Topics for future STEM Talks

About Us:

A nonprofit that supports local education in Science, Technology, Engineering & Math (STEM)

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College Scholarships (Rising Stars)

Hands-On Demos

STEM Origins Foundation

STEM Student of the Month

STEM Equip for Classrooms

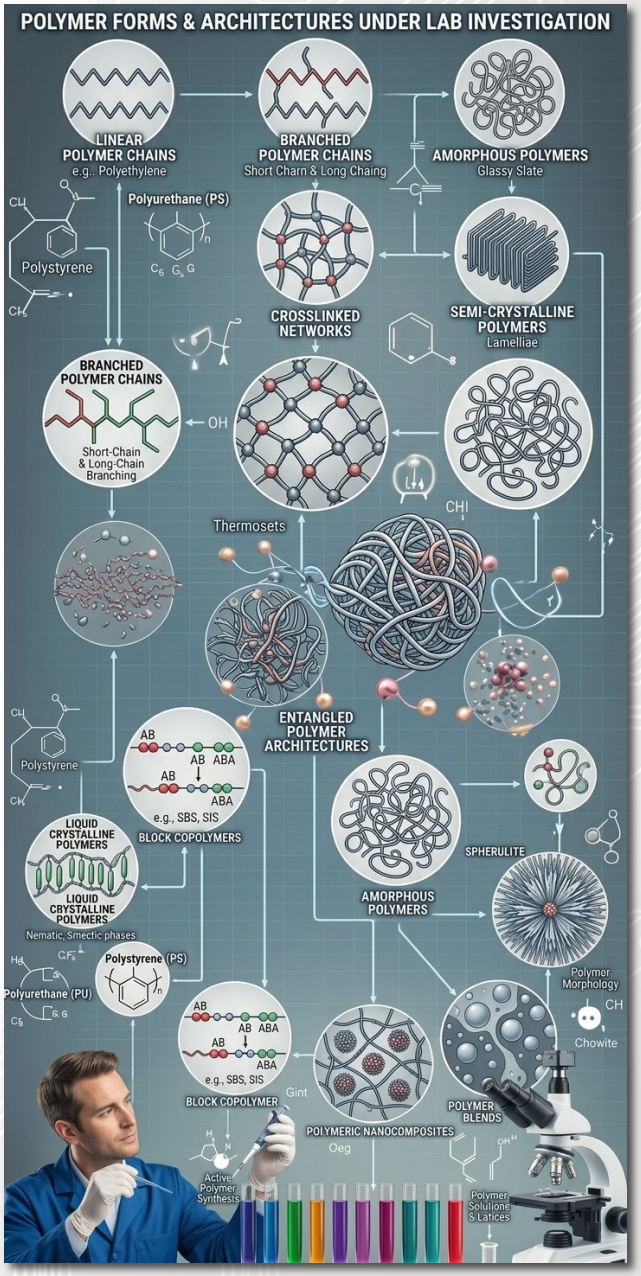
Founded by LMWS Residents

Run by Volunteers*

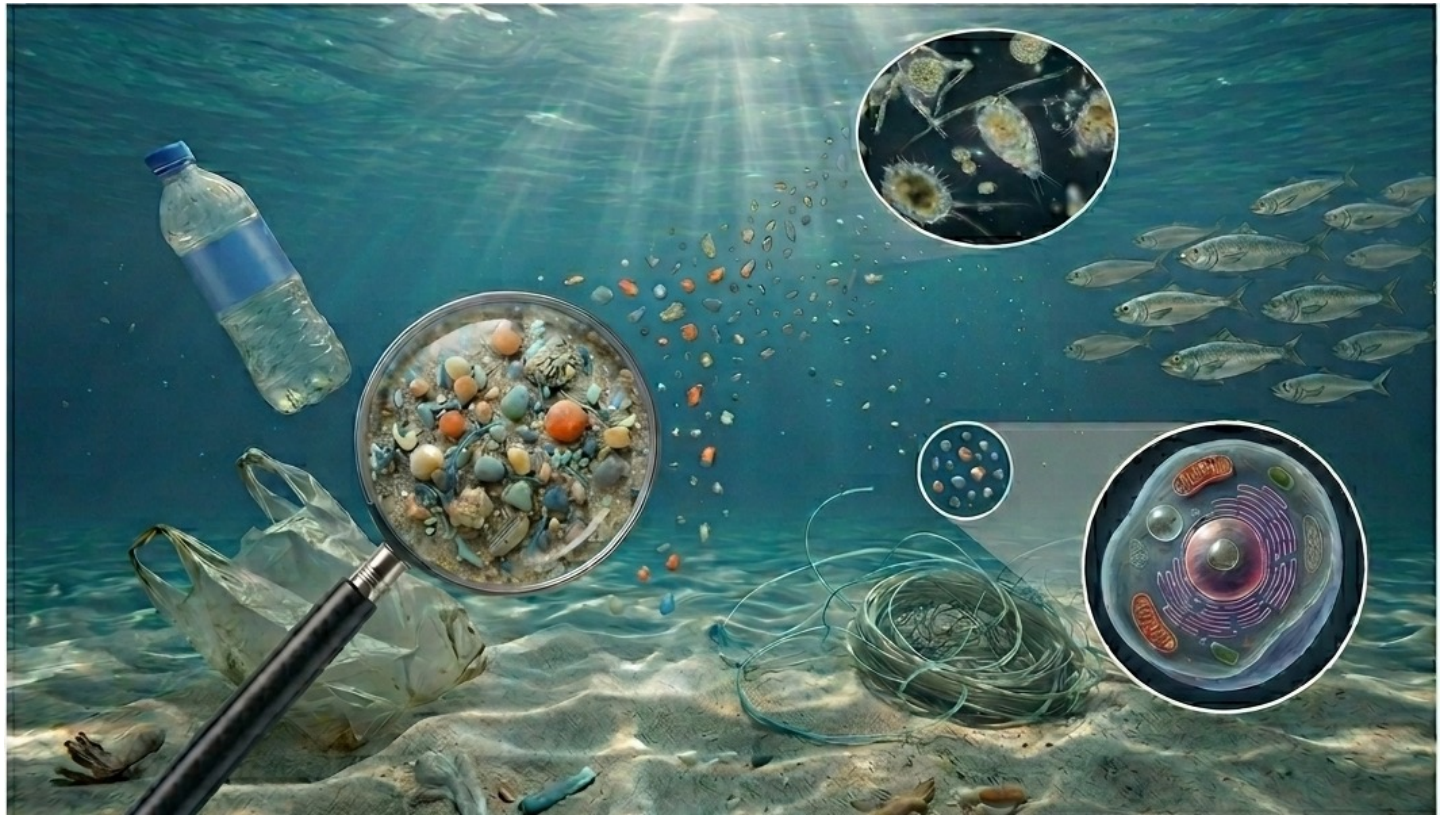
- Always looking for good people
- All walks of life are welcome

Today's Speaker: Dr. Brian Maxwell

- Over 40 years experience as an Organic Chemist
- B.S. in Chemistry from UT in Knoxville
- PhD in Organic Synthesis from UC Berkeley
- Worked in Research and Development in Chemical Industry
- Designed and made many types of chemical compounds and ***polymers***, incl:
  - Dyes, Colorants
  - Radio-labelled compounds
  - Polymers for adhesives, paints and protective coatings, etc.
- Managed groups of chemists to design new products that made:
  - Paints easier and safer to apply,
  - Tires that got better traction and better gas mileage, etc



MICROPLASTICS: *What are they and should I be worried?*



A guided look into what microplastics are and their potential impact on human health and environment

by Brian Maxwell, PhD.

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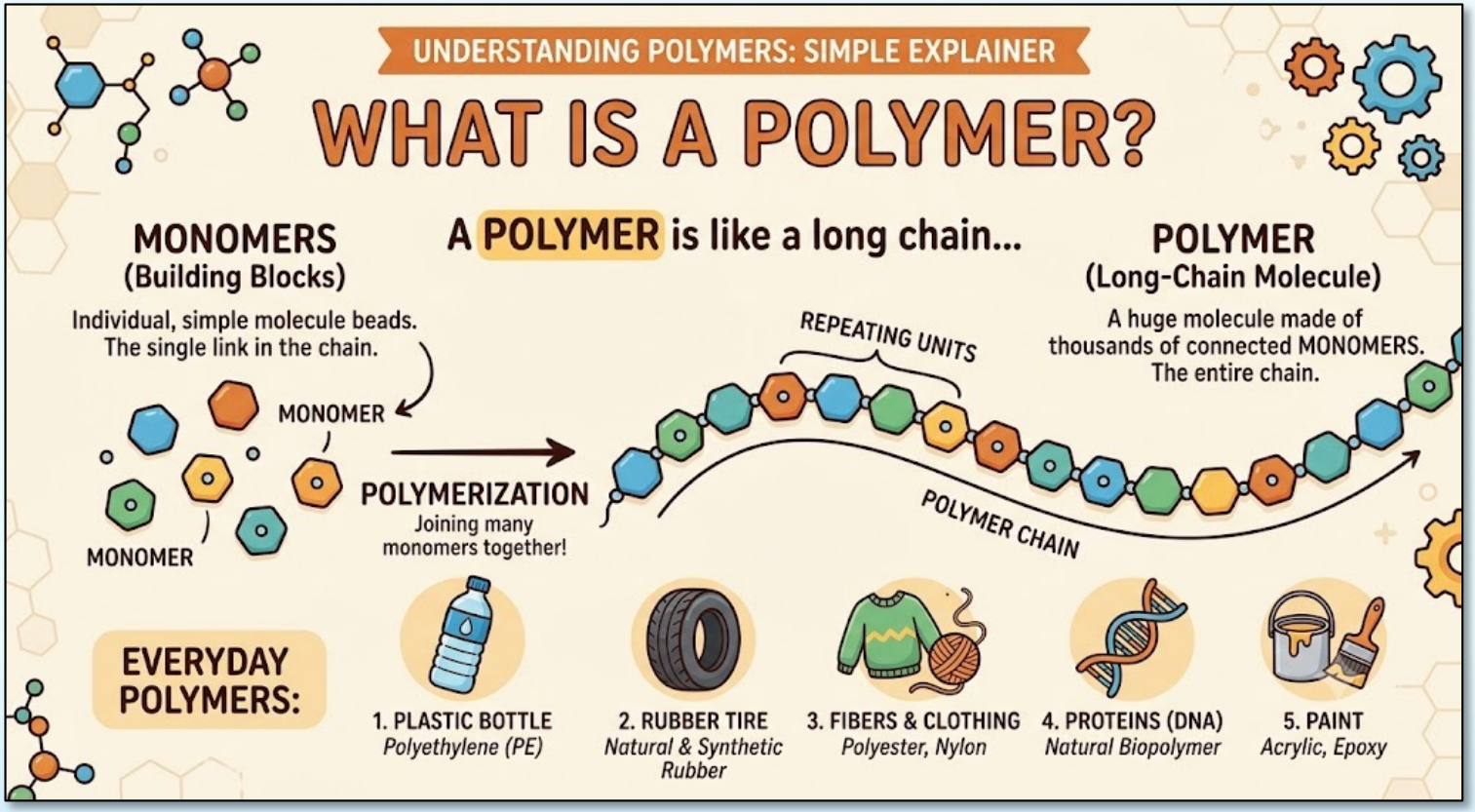
Microplastics

- You may have heard the term “Microplastics” in the news media or even in advertisements for water filters.
- You may have heard that microplastics pose a serious threat to the environment and/or your health.
- Like so much in the media these days, it is sometimes hard to separate fact from speculation or even fantasy.

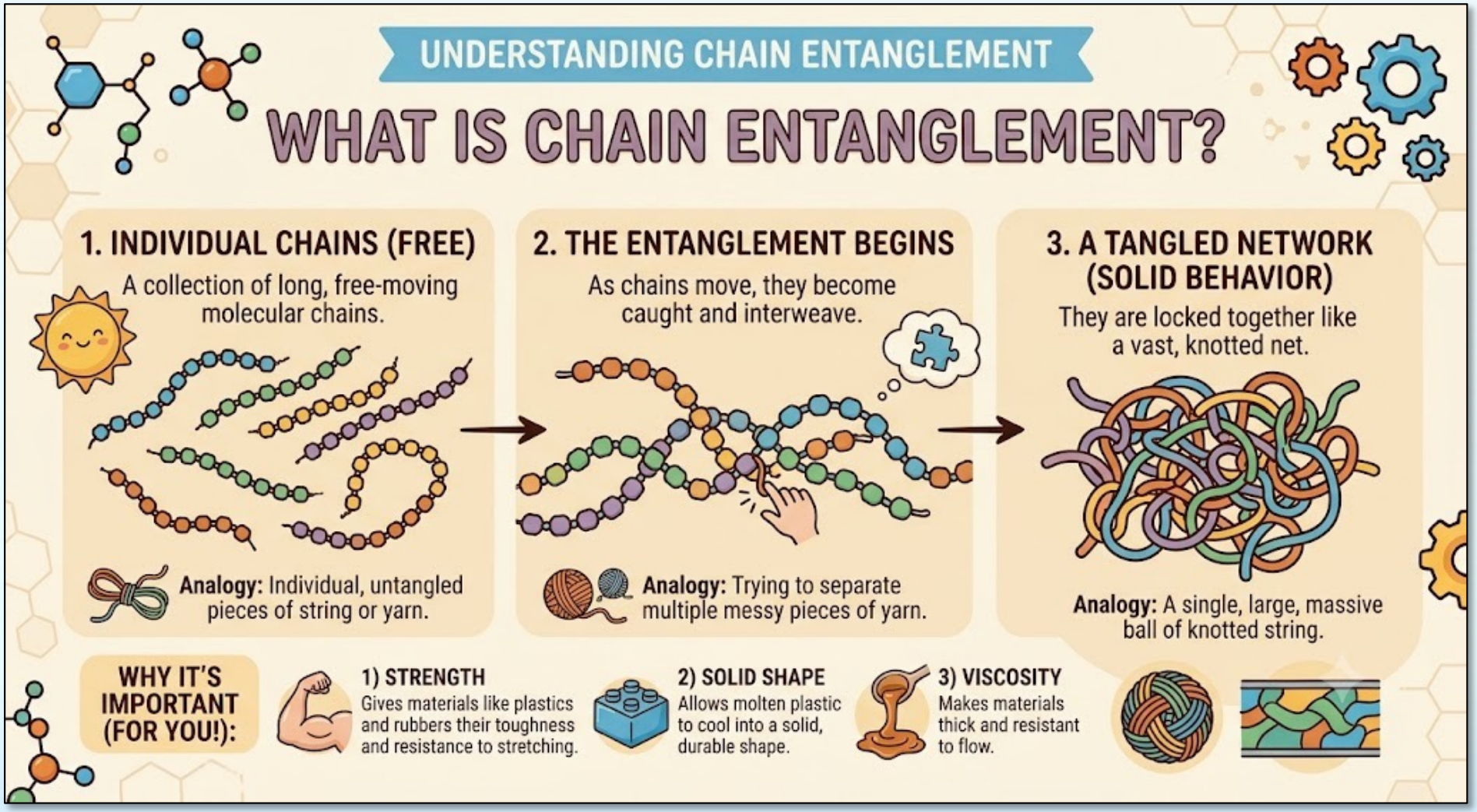
What is a plastic?

- Plastics are man-made polymers which vary widely in composition but can be found in almost all facets of our daily lives.



Common Polymers a.k.a. Plastics

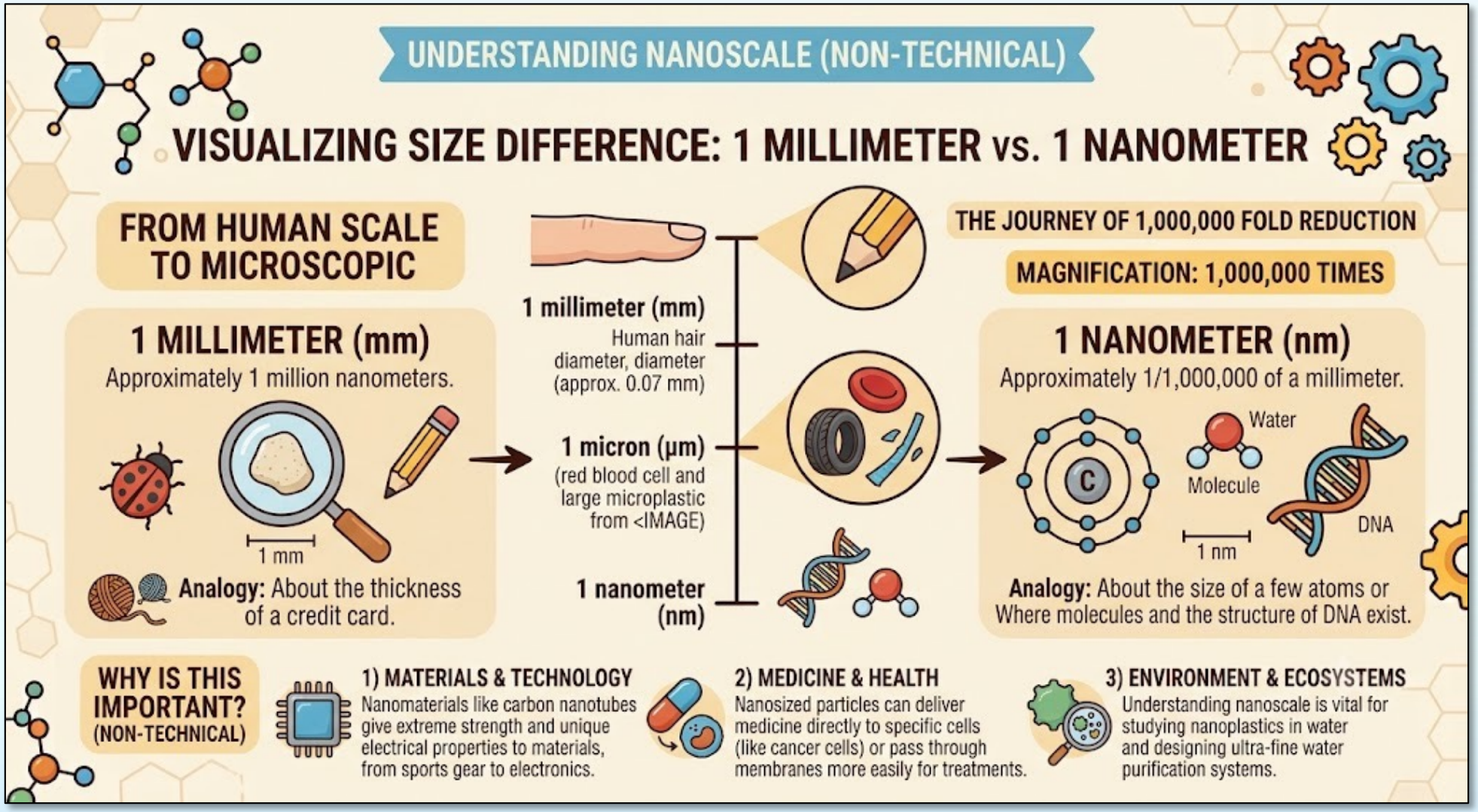
Chains & Entanglement



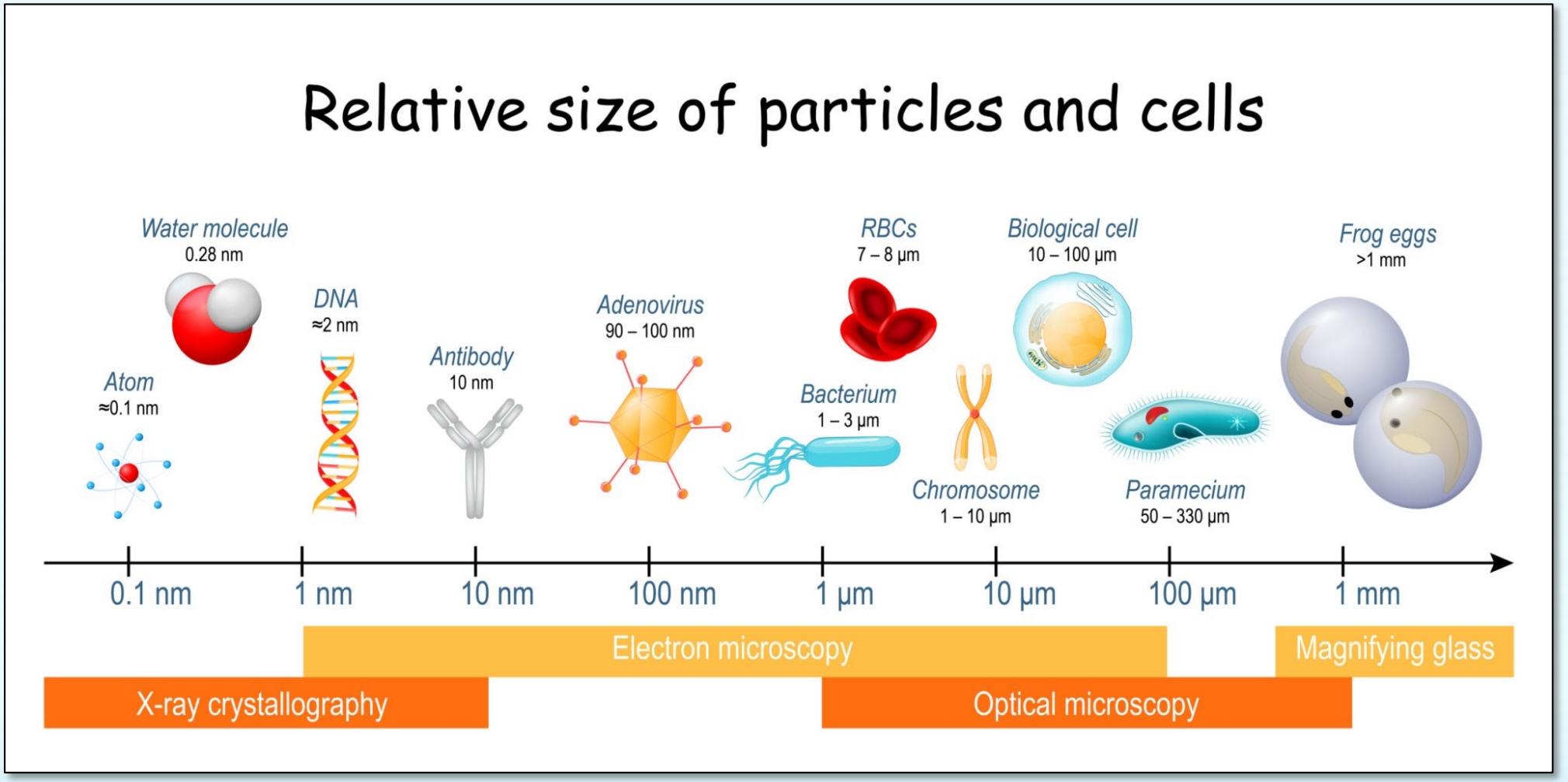
Definition of "Microplastics"

- Most Organizations Define Microplastics based on size rather than composition or form.
- The consensus appears to be that any plastic particle smaller than 5 mm (0.2 inches) and generally larger than 1 nm (nanometer) is considered a microplastic particle.
- Europe also includes synthetic fibers between 15 mm and 3 nm as microplastics.
- The Internation Standard Organization subdivides Microplastics into:
  - Microplastics: 1 mm down to 1 µm (micrometer, micron)
  - Nanoplastics: 1 µm down to 1 nm
  - Large Microplastics: 5 mm down to 1 mm

How Small is Small?



How Small is Small?



How are Microplastics Formed?

- Abrasion
  - Rubbing, grinding, scraping plastic articles can break off small pieces
  - Sanding painted articles tears off small pieces of plastic/paint
  - Bending and flexing can cause microfractures that create small particles
- UV/Solar radiation
  - Some plastics are sensitive to UV degradation especially in contact with oxygen in the air. The degraded polymer chains may be more brittle leading to fragmentation
  - Polyethlyene grocery bags are susceptible to this type of degradation.
- Chemical attack
  - Some plastics are susceptible to chemical attack by strong acids or bases. This can lead to polymer chain breakage and fragmentation
  - PET (water bottles) are susceptible to such chemical attack.
- Direct Production
  - Small particles of plastic are intentionally made for products like latex paint, face-wash and some toothpastes where small particles (1 – 100 microns) are required.

Where are they Found?

- Air
  - Small fibers from clothing and small particles from abraded plastics can become airborne. Like dust and pollen, these particles can travel significant distances on the wind.
- Water
  - Microplastics will be washed by rain into streams and rivers and eventually the oceans.
  - Large, discarded plastic articles will break down through UV and mechanical abrasion in water (wave action).
- Soil
  - Some microplastic particles will become part of the soil.
  - Microbial activity might break down these particles more rapidly than in air or water.

Microplastics in Air

- Most appear to be very small fibers
  - They are light enough to be blown about by the wind
  - Mostly from clothing (lint)
- Spherical particles are too dense to float in air

Microplastics in Water

- Currently, there is no reliable measurement of the number of microplastic particles found in water or soil
- Number of particles increases with decreasing size for a given weight.
  - 1 gram of polymer can be billions of small particles (< 1 micron) or 1 large pellet
- Reliable methods for testing and counting are still under development
- Filtration can get the larger particles (> 1 micron)
- Reverse Osmosis can keep microplastics from water.

Water Filtration Efficiency

Filtration Type	Average Pore Size	Microplastic Removal Efficiency	Best For
Reverse Osmosis (RO)	~0.0001 microns	**99.9% +**	Virtually all microplastics and most nanoplastics.
Ultrafiltration (UF)	~0.01 to 0.02 microns	**98% – 99.9%**	Sub-micron plastics while retaining healthy minerals.
Microfiltration / Ceramic	~0.1 to 0.2 microns	**90% – 98%**	Standard microplastics (excluding nanoplastics).
Activated Carbon Block	~0.5 to 10 microns	**80% – 95%**	Larger microplastics, chlorine, and organic chemicals.
Granular Activated Carbon (GAC) / Pitchers	Variable (No uniform barrier)	**Highly variable (<50% to 80%)**	Basic taste/odor; poor at trapping tiny microplastics.

What is the Impact?

- Wildlife
  - Microorganisms might mistake the microplastics for food and ingest them. This can clog digestive organs and cause death
  - It is unclear at this point if larger organisms suffer health effects from ingesting microplastics.
  - Microplastics can absorb chemicals which could affect wildlife if ingested.
- Soil
  - Microplastics might affect soil structure. Most plastics are not water absorbing and might affect water retention.
  - Microplastics can absorb chemicals which could affect soil treatment protocols.

Scientific Uncertainty

- Measuring and counting Microplastics is difficult!
  - There is a lack of analytical methods that can detect very small particles
  - Microplastics are everywhere, leading to contamination of samples and instruments.
  - As particles get smaller, other materials might look like Microplastics
- Scientific Fraud is on the rise!
  - Academic advancement depends on publication of papers. The pressure to produce meaningful research is enormous.
  - Research is expensive and time consuming. A carefully designed study with proper controls can take years and may not support your theory.
  - Peer review has broken down in many high profile cases

Scientific Fraud Claims

- Scientific Literature Journals are Sounding the Alarm
  - "Peer-Review Fraud — Hacking the Scientific Publication Process", N Eng J Med, 2015;373:2393-2395
  - Wikipedia, List of Scientific Misconduct Incidents
  - Retraction Watch – Website dedicated to holding scientists responsible.
- "Paper Mills"
  - There are commercial enterprises that are generating scientific sounding articles to promote products or attack initiatives.
  - These paper mills do not conduct science but publish false or misleading data for commercial or political gain.

What to Believe?

- There is good, rigorous, scientific research being done!
- Search carefully and read carefully.
- Good research identifies sources of error and explains how the study mitigated the error.
- The truth will come out over time. Don't rush to judgement.

Impact on Humans

- Respiratory
  - The inhalation of any small, solid particle into the lungs is problematic.
  - There are claims in the literature that microplastics cross the lung/blood barrier. These claims are in dispute.

- Ingestion
  - The gut/blood barrier is designed to prevent non-nutritive particles from crossing into the blood stream. Most non-nutritive materials are eliminated as waste.
  - There are claims in the literature that microplastics have crossed the blood/gut barrier. These claims are in dispute.

Impact on Human Respiratory Function

- The inhalation of any small, solid particle into the lungs is problematic.
  - Black Lung Disease (coal dust)
  - Brown Lung Disease (textile fiber (cotton, rayon, etc))
  - Silicosis (fine sand or silica particles)
  - Asbestosis (small asbestos fibers)
- There are claims in the media that microplastics cross the lung/blood barrier. These claims are in dispute
- The air is, in general, cleaner today than in the past several centuries.

Impact on Human Digestive Tract

- Many initial studies that claimed to have found microplastics in the blood stream were flawed.
  - Microplastics are everywhere including in laboratories and scientific instruments. Extreme care must be taken to eliminate sources of microplastics when looking for them in blood.
  - Lipids in the blood stream were mistaken in some tests for microplastics.
- More rigorous, recent studies claim to have found microplastics in the blood but the amount and impact are unknown.

Impact on Human Digestive Tract

- Size Matters!!!!!
  - Microplastics > 150 micron (0.15 mm) absolutely cannot cross the gut/blood barrier
  - Microplastics < 1 micron **MAY** be able to cross by the mechanisms below, but there is uncertainty on how often this happens.
  - In between, there is a lot of discussion but no consensus at this point
- Health Matters!
  - A healthy gut is more resistant to microplastics than an unhealthy gut.
- Mitigation of Microplastics in food and drinks.
  - Use filtered water when possible
  - Wash food and avoid highly processed food.

How can Microplastics get into the Blood Stream?

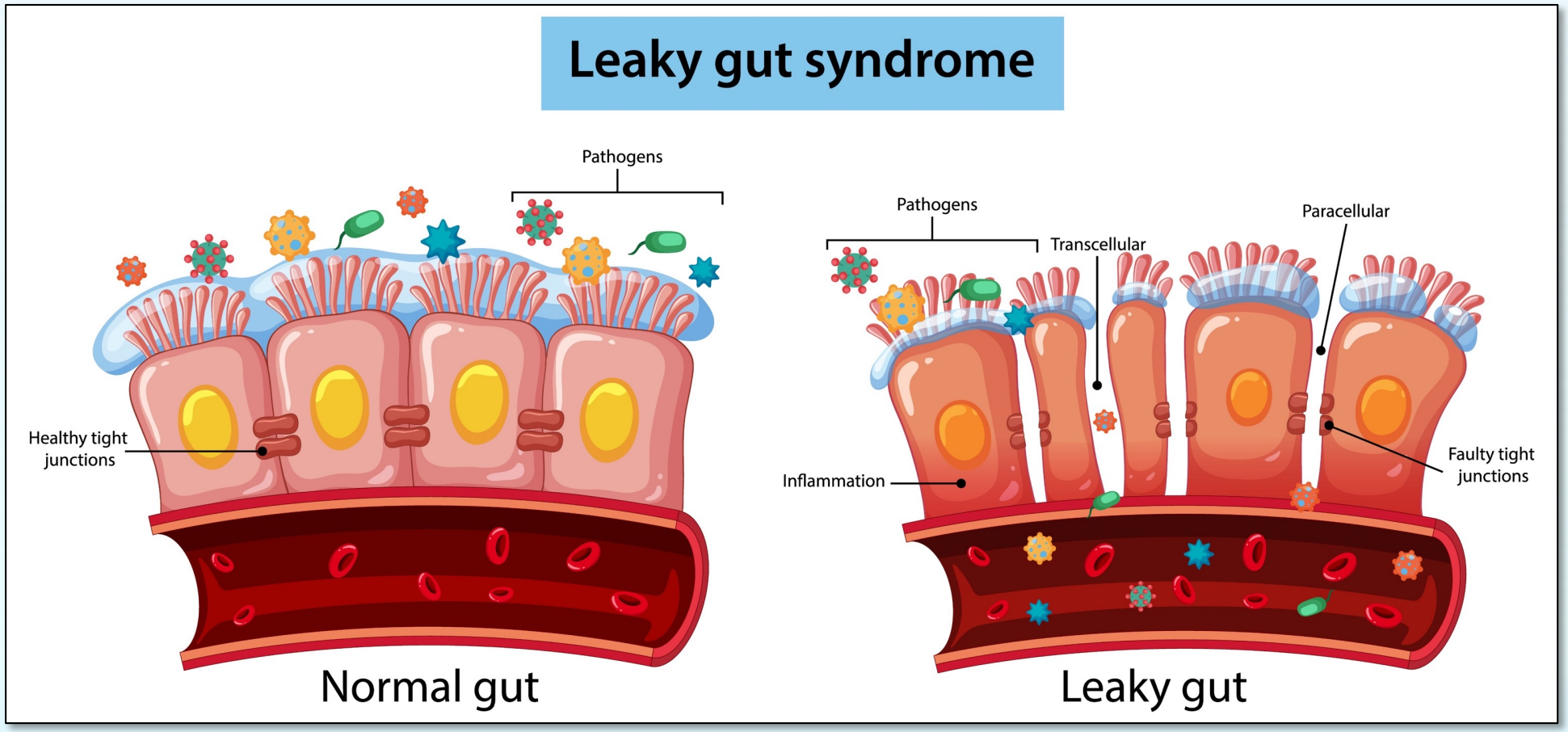
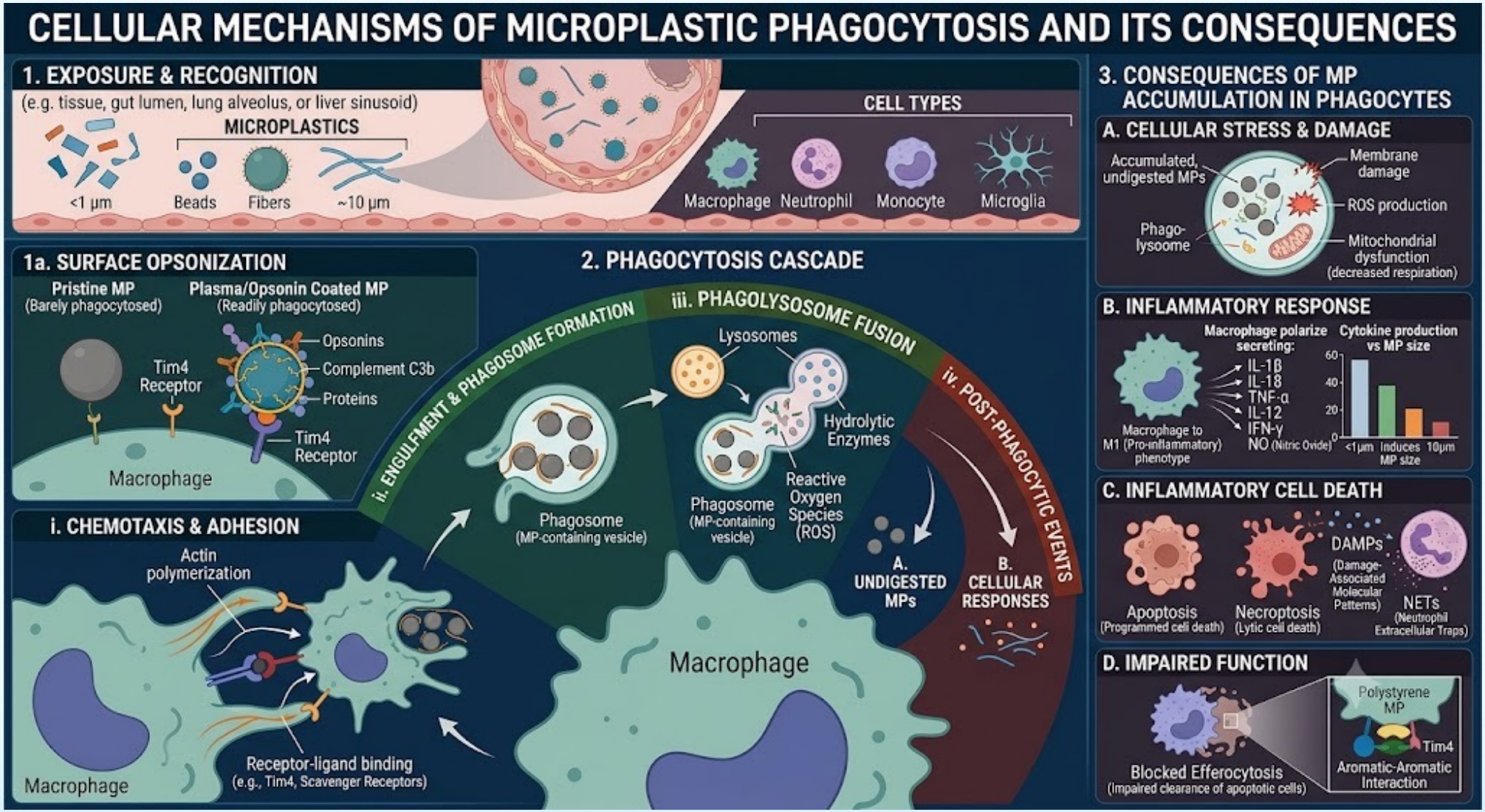


Image by brgfx on Magnific


CELLULAR MECHANISMS OF MICROPLASTIC PHAGOCYTOSIS AND ITS CONSEQUENCES
1. EXPOSURE & RECOGNITION
(e.g. tissue, gut lumen, lung alveolus, or liver sinusoid)
MICROPLASTICS
<1 µm
Beads
Fibers
~10 µm
CELL TYPES
Macrophage
Neutrophil
Monocyte
Microglia
1a. SURFACE OPSONIZATION
Pristine MP
(Barely phagocytosed)
Plasma/Opsonin Coated MP
(Readily phagocytosed)
Opsonins
Complement C3b
Proteins
Tim4 Receptor
Tim4 Receptor
Macrophage
2. PHAGOCYTOSIS CASCADE
i. CHEMOTAXIS & ADHESION
Actin polymerization
Receptor-ligand binding
(e.g., Tim4, Scavenger Receptors)
Macrophage
ii. ENGULFMENT & PHAGOSOME FORMATION
Phagosome
(MP-containing vesicle)
iii. PHAGOLYSOSOME FUSION
Lysosomes
Hydrolytic Enzymes
Phagosome
(MP-containing vesicle)
Reactive Oxygen Species (ROS)
iv. POST-PHAGOCYTIC EVENTS
A. UNDIGESTED MPs
B. CELLULAR RESPONSES
Macrophage
3. CONSEQUENCES OF MP ACCUMULATION IN PHAGOCYTES
A. CELLULAR STRESS & DAMAGE
Accumulated, undigested MPs
Membrane damage
ROS production
Phago-lysoome
Mitochondrial dysfunction
(decreased respiration)
B. INFLAMMATORY RESPONSE
Macrophage to M1 (Pro-inflammatory) phenotype
Macrophage polarize secreting:
IL-1β
IL-18
TNF-α
IL-12
IFN-γ
NO (Nitric Oxide)
Cytokine production vs MP size
60
40
20
0
<1µm
Induces
10µm
MP size
C. INFLAMMATORY CELL DEATH
Apoptosis
(Programmed cell death)
Necroptosis
(Lytic cell death)
DAMPs
(Damage-Associated Molecular Patterns)
NETs
(Neutrophil Extracellular Traps)
D. IMPAIRED FUNCTION
Blocked Efferocytosis
(Impaired clearance of apoptotic cells)
Polystyrene MP
Tim4
Aromatic-Aromatic Interaction

Another Source of Microplastics in Blood

- Medicine uses plastics in almost every phase of treatment
  - Tubing, syringes, bandages, scalpel holders, etc.
- Some microplastics could be introduced into the blood stream during:
  - Injections
  - Blood Transfusions
  - IV fluids
  - Surgery

Health Effects of Microplastics

- There are many articles that speculate on how microplastics could impact human health.
- Some of the claims:
  - Inflammation of tissue leading to increased risk of infection
  - Abnormal organ function or development
  - Increased risk of illness or death
- There have been NO credible papers published that have shown ANY health effects from microplastics at this time.

So, What Do We Know?

- Microplastics are very small pieces of polymers that can be found everywhere in our environment
- Early Studies and Reports greatly overestimated the amount of microplastics in the environment
- Most media stories on the potential impact of microplastics cite these early studies and conjecture on the impact
- Quantification of microplastics is a serious scientific challenge and is the focus of much research
- There are credible reports of microplastics in human blood samples. There are several possible routes for this finding

What Can We Do?

- **Don’t panic!!**
- Filtered water is probably a good idea.
- Eating fresh foods (washed) and less processed foods should also help
- Gut Health is important.
- **There have been NO credible published findings of harm due to microplastics but there are groups studying this.**

Should You Worry?

- In my opinion, worry is more damaging to your health than the threat of microplastics
- Mankind has survived much higher concentrations of airborne particulates than we face now. I don't believe airborne microplastics are a high risk for health.
- Ingestion of some microplastics seems unavoidable but the impact on human health is unknown despite the frantic media reports.
- Our bodies are designed to handle indigestible matter and there is no reason to think that microplastics will be treated differently from bits of sand (silica) or char (carbon).

Questions?

Thank You for Coming!

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- **Next STEM Talk:** is on 28 Sep
- **Topic:** How to Design buildings for Earthquakes, Hurricanes & Tornadoes
- **Open Invitation:** to new Briefers & Topics for future STEM Talks