Nuclear Powered Plankton

Ed Ward, USA

No, not really. But my favorite plankton collecting location is 10 kilometers downstream from a nuclear power plant. I haven't discovered any crazy plankton mutants, but the cooling system of the power plant discharges tons of warm water into the river. The big bonus is that I can collect plankton from the Mississippi River year round, despite the river being seasonally frozen over further upstream and downstream (I live in Minnesota in the north central US, with typically very cold winters). I like seeing the plankton populations in my net change with the seasons and sometimes even more quickly. I've noticed several patterns.

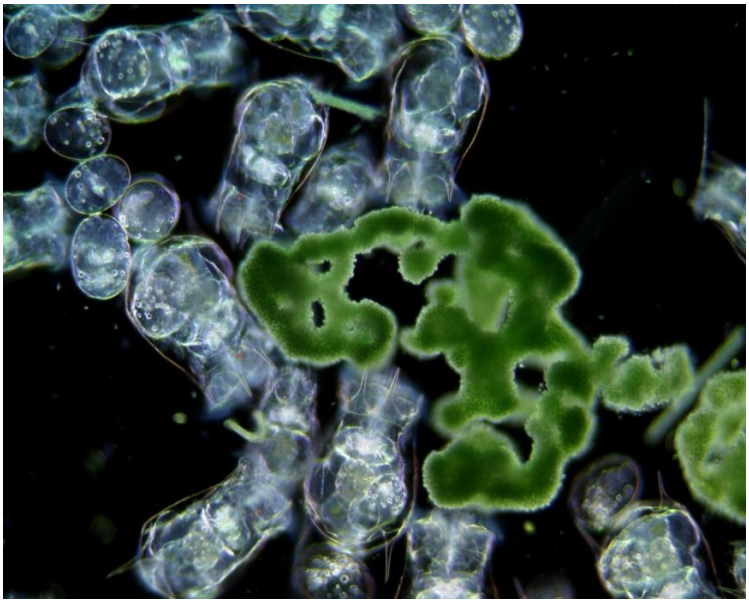
Plankton definitions

Plankton (from Greek for "drifter") is all the living things that live suspended in the water column. Although we thank about marine scientists using special nets to capture tiny things in the ocean, plankton can be in salt water, brackish, or freshwater. Oceans, bays, estuaries, lakes, rivers, ponds and marshes can all have plankton. Ponds and even puddles tend to have more than big lakes and rivers. In still bodies, cloudy water can be a promising sign for plankton hunters, although rivers and puddles can be cloudy from mud or clay particles.

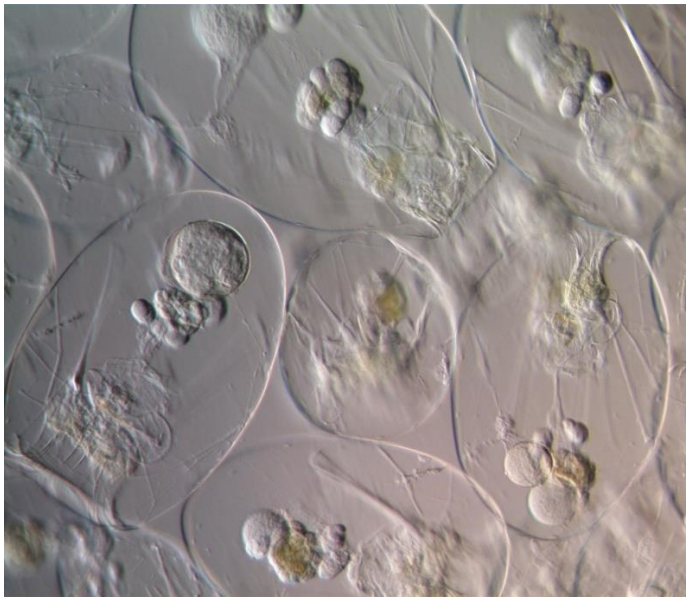
Plankton are not living on the bottom (benthic) or swimming (pelagic). At a microscopic scale many can swim, but not enough to move against current. Some plankton does move up or down by swimming or using controllable air bladders, often down into the depths for daytime protection and up near the surface at night. Although mostly small, drifters include jellyfish (including the lion's mane jellyfish with 36 meter long tentacles) which are also plankton. Much plankton is very small or microscopic down to bacteria and archaea (prokaryotes typically about 0.2 to 2 microns long) and viruses (mostly about 0.02 to 0.1 microns or 20 to 100 nanometers, although giant mimiviruses can be 0.5 micron). The size of plankton I catch in my net with 0.1 mm openings (fairly coarse for a plankton net) is called mesoplankton (forms 0.2 to 20 mm) and microplankton (forms 0.002 to 0.2 mm or 20 to 200 microns). Plankton that makes their own food (autotrophy) includes algae of several kinds including diatoms ("brown" algae in intricate silica shells), green algae and blue green algae (aka cyanobacteria) and is called phytoplankton. It forms the photosynthetic base of the food chain. Cyanobacteria are very abundant photosynthetic prokaryotic (no organized nucleus) bacteria that may form visible filaments. The animals and heterotrophs (things that eat something else for energy) are zooplankton and include protozoa (complex eukaryotic single celled organisms on their own diverse branch of life including amoeba, flagellates and ciliates) and many kinds of small animals (crustaceans including copepods, cladocerans aka waterfleas, amphipods, ostracods, other animals such as jellyfish, rotifers, tiny worms from several phyla, and larval forms of some crustaceans, insects, mollusks and others). And some plankton don't like binary trophic pronouns and are called mixotrophs. This includes dinoflagellate protists, which sometimes photosynthesize, sometimes eat, and sometimes cause harmful red tides.

Microscopic predator-prey pattern in 2 planktonic rotifers

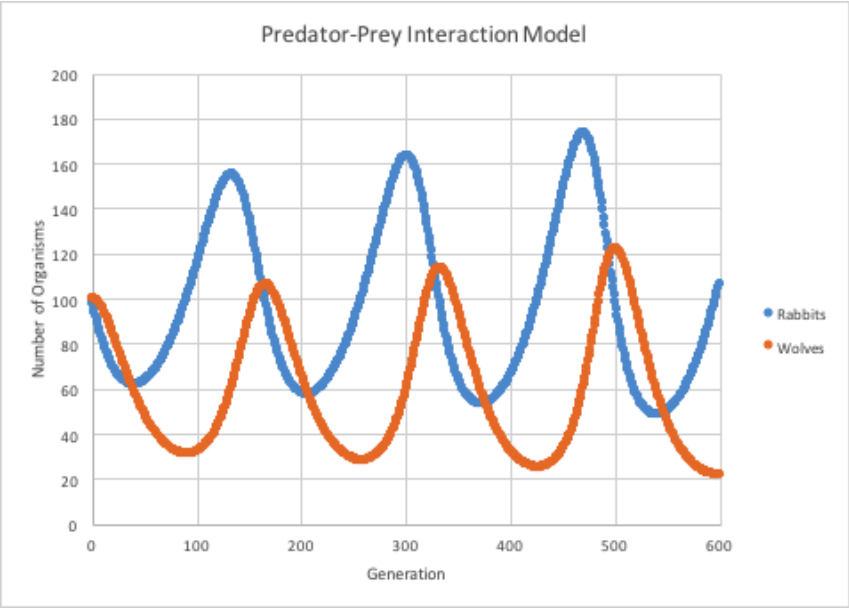
If I see a lot of the rotifer *Brachionus* in my net, I know there will likely be a lot of *Asplanchna* about 3 weeks later, then both populations will probably crash soon after that. *Brachionus* eats tiny organic debris particles, bacteria and small algae. *Asplanchna* is a big, baggy, transparent predator rotifer, eating mostly *Brachionus*. The prominent spines of *Brachionus* evolved in part to make it harder for *Asplanchna* to swallow. *Brachionus* has an average lifespan of less than a week, lowered further when lots of predators are present. *Asplancha* releases a "semiochemical" that induces longer spines in *Brachionus*. It's co-evolution on steroids. The two free-swimming rotifers trace a quick predator prey population pattern, with abundant prey boosting predator populations which then eat so much of the food species that abundances of both rotifers then falls temporarily.



Brachionus (and *Microcystis* cyanobacteria) 10X dark field



Asplanchna 10X objective, oblique lighting



Left is an idealized mathematical population model of rabbits and wolves (from Northern Arizona University)

Brachionus, above left is the "rabbit" and Asplanchna, above right is the "wolf"

My plankton collecting net

I also dip plastic jars into puddles and marshes, but will concentrate here on my use of a homemade plankton net. I tried a few other methods, but have used my current plankton net for over 5 years with good results. I usually ride my bike about 5 kilometers to the Mississippi River and a nearby fishing pond to use the net.

Plankton net made from nylon mesh honey strainer, 34 cm dia., 40 cm deep, rim is fabric and wire reinforced. 3 holes punched in rim by red not nail, tied with good quality synthetic twine; 2 half hitches and overhand knots on a bight work well. The chain link adds needed weight; mini carabineer allows quick attachment to any post or rail.

The honey filter costs $10 US for 2 on Amazon. It is very good for plankton just by adding strings; the rim is plenty strong as it comes from the maker.

The mesh openings are about 0.1 mm/ 100 microns, so a lot of smaller plankton is lost, but flow is excellent, the mesh is easily cleaned and the net still catches lots of plankton. The bottom of the net is sewn shut by the manufacturer. I tried cutting the tip off and attaching small jars and vials with a rubber band. It worked, but I didn't get even a tenth of the plankton I get by using the intact net. I either let the river current fill the net for about 5 minutes while a 1 to 2 meter long cord is clipped to a railing, or I drag the net with an outstretched arm as I walk about 10 meters around the perimeter of a fishing dock. I then fill a 5 cm tall 3 cm diameter clear acrylic plastic screw top specimen jar (sold to hold jewelry parts) half full of lake or pond water. I turn the plankton net inside out and shake the tip of the net in the water in the jar to wash off the cloudy soft pellet of plankton. I dunk the bottom of the net back in the water a few times, and swing the net around in a circle to let centrifugal force get most of the water out. I then put the net into a thin clear plastic bag (the disposable kind used in produce departments in US grocery stores is a perfect fit) and then an outer plastic grocery bag and wrap and clip the cord on (doing this carefully minimizes tangling). At home I repeatedly rinse the net in tap water, gently rubbing the net against itself to help clean it, then hang it to dry. I've used the net probably over 100 times without any signs of damage. I love my cheap homemade plankton net.

My Plankton Collecting Kit

Riding a bike, I keep my collecting equipment in a small backpack for easy carrying. I usually also carry a few plastic coin cases. They are easier to use in the field than microscope slides and a bit of plankton can be shown and even given to curious onlookers. If I want a larger water or plant sample, I'll also carry a wide mouth 1 L plastic jar (originally held mixed nuts).

1. backpack
2. extra magnifying glasses, coin cases and educational materials to give to curious kids
3. clear specimen jars for plankton
4. plankton net in plastic bags
5. about 15X loupe
6. microfiber towel
7. cheap 40X hand "microscope"
8. reading glasses (I have become presbyopic)

Most of my kit is self-explanatory. I have also added some things to give away (item 2. above). For $1.25 US at the "dollar store" I sometimes buy nice 9 cm diameter magnifying glasses or so-so 4 cm magnifiers with a built-in flashlight. I've also found a case of 50 linen readers at a good discount, and one can get "30X" loupes (Chinese, likely about 15X but optically pretty good) for about $2 each in bulk on US eBay. I wait until a family with kids shows an interest in my netting activity (it doesn't happen that often) then give the kids a magnifying glass, a coin case with plankton and a tiny dropper to refill it. I also include my own educational flyers on using a magnifying glass, how to care for a plankton "microaquarium", and "thank your Plankton" on the following pages of this article. I've also done demonstrations in elementary school classes. Giving away a hundred magnifiers might turn one or two kids on to science, probably improving their lives and potentially everyone else's if they become the next Charles Darwin. I believe and want to share that our world is full of unexpected complexity and beauty, and that science is the best way to understand the world.

Thank your Plankton

(this is a simple 1 page report I give to curious onlookers)

Plankton are tiny plants and animals floating in fresh and salt water. As a by-product of photosynthesis (sucking up carbon dioxide and sunlight to make food) zillions of tiny plankton produce 50-70% of the oxygen you breathe, and they start aquatic food chains.

Algae (green protists) under microscope

Plankton was first clearly seen by Leeuwenhoek with his microscopes around 1670

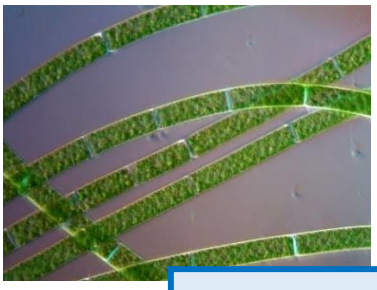
Copepod, ~ 1 mm long shrimp relative, the most common animal on earth

Most (not all) are tiny and they all float or swim along with currents; plankton means “drifter” in Greek. Most plankton is in the oceans, but freshwater ponds lakes and rivers have it too. Plankton is all kinds of living things including some too tiny to be caught in most nets such as viruses, bacteria and smaller protists (one-celled living things that aren’t plant or animal). **Phytoplankton** is plants as single cells, clusters or chains (green algae, brown algae diatoms, and many others). **Zooplankton** are zillions of little animals including copepods, “water fleas” and other crustaceans, jellyfish, tiny worms, and others. Many zooplanktons are drifting their whole life but some are planktonic only as eggs or larva. Plant plankton is food for animal plankton which is eaten by tiny fish fry which are eaten by bigger fish, which maybe you’ll eat.

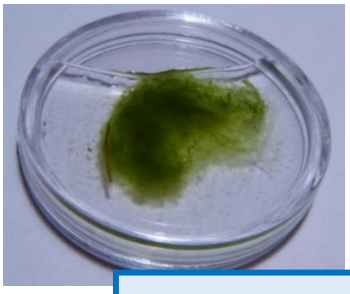
Sometimes the water is so thick with plankton as to be slightly cloudy. But most places the plankton is thinner. Put a gallon of lake or ocean water in a gallon jar and look carefully with good light and you’ll probably only see a few tiny dots swimming jerkily along. Most will be so small you need a microscope to see them clearly. To gather more plankton to study scientists (and you too, if you want) use a plankton net. I made mine out a honey strainer net bought on the internet, with strings tied to it. A plankton net can be towed behind a boat, lowered into a river or dragged by hand around a dock. A little cloudy pellet collects in the end after a while. Turn the net inside out and wash the soft mass into a small jar. You now have many thousands of plankton organisms to explore with a magnifying glass or microscope.

Plankton net made from honey strainer

Ed Ward
Red Wing, Minnesota



Spyrogyra algae, may float on surface

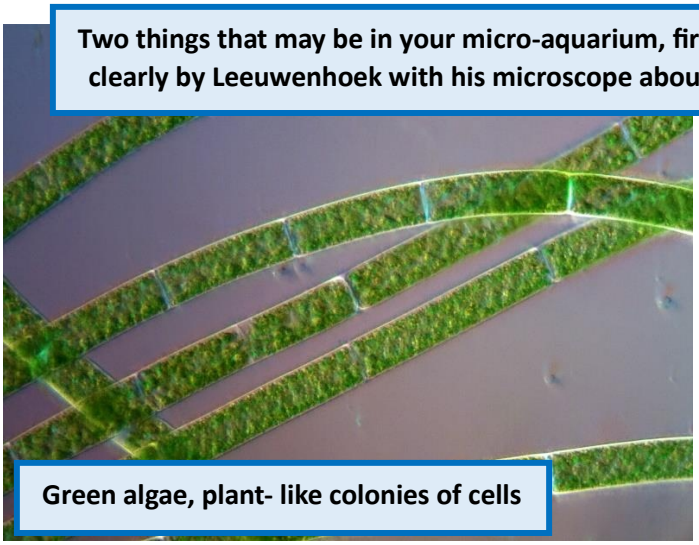


Coin case as plankton microaquarium

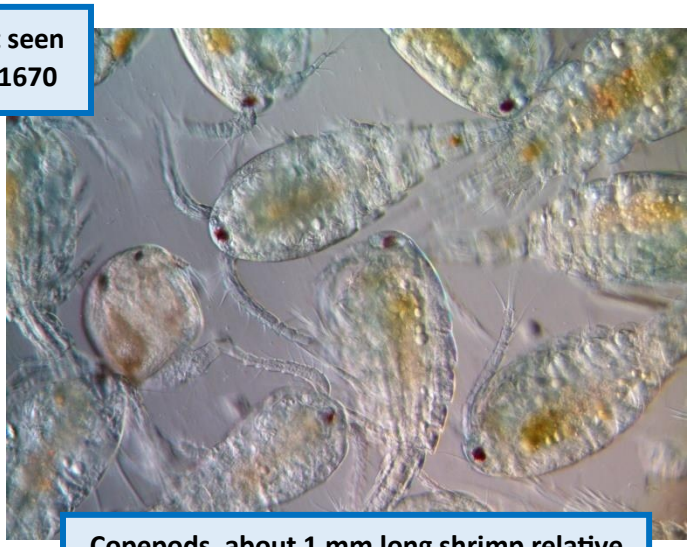
Your ‘Micro-aquarium’

The small plastic container contains about 1 milliliter (20 drops) of pond water and a small air bubble. It also contains green plant-like livings things and some tiny animals. Look carefully with a magnifying glass in good light and you might see crustaceans such as copepods darting about or tiny nematode worms wriggling. With a microscope you could see even more.

Two things that may be in your micro-aquarium, first seen clearly by Leeuwenhoek with his microscope about 1670



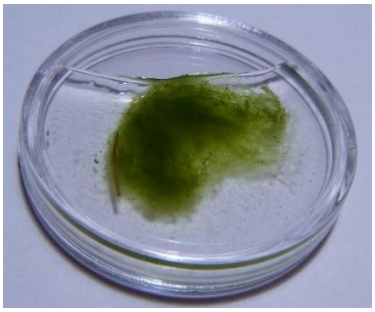
Green algae, plant- like colonies of cells



Copepods, about 1 mm long shrimp relative

It’s also a ‘Micro-biosphere’

Because the container has water, air, plants, animals and decomposers (bacteria are there, but so small a powerful microscope is needed to see them), the micro-aquarium can function for a while as a sealed off complete ecosystem. Green algae make food and oxygen from light, then are eaten by animals that make carbon dioxide that is used by plants. Things die and are broken down by bacteria, and the chemicals of life are recycled so plants and animals can grow again. Our planet earth, floating in space, sealed off except for input of light from the sun does the same trick (on a huge scale), with the total of all life recycling everything it needs.



Care of your micro-aquarium

Place your micro aquarium on a windowsill or under a desk lamp for light. Not too much direct sunlight- don’t cook your biosphere. Unlike the earth, your biosphere is not perfectly balanced so the animals may die after a few days or weeks, and eventually the water will dry up. When you decide to, you can empty the container (find the small opening for a fingernail along one side and pry open), collect interesting pond water specimens and start over.

Micro-aquaria and demonstrations provided by Ed Ward, in Red Wing, Minnesota

Using a magnifying glass
suggestions for curious kids

Ed Ward, Red Wing, Minnesota

If you look closer, most things become more beautiful and complicated. Magnifying glasses help you to explore your world. I used them as a kid, got into science, and having older eyesight I still use magnifying glasses today.

Some people will start exploring **indoors**. Look at anything you want and use a flashlight or other bright light to help see more clearly with the magnifying glass. Some things that might look interesting are print and pictures in books, stamps, coins, salt and pepper, clothing, the screen on a cell phone, dust or dryer lint, the tip of a nail or needle (get help from an adult).

Going **outside** is even better. Robert Hooke (one of the first to use microscopes for science, he wrote and illustrated *Micrographia* in 1665) noticed manmade objects might look less perfect but things from nature usually look more beautiful when magnified. Go on a nature hike (get help from an adult if you are young) and look at things with your magnifying glass. Lay down to get a good look in the dirt and grass. Bring back rocks, sand, leaves, flowers, pinecones, mushrooms, twigs, snail shells, insects and other bugs in jars or bags to look at again later.

Mississippi River sand is beautiful tiny rocks

Photos through low power microscopes

Horseflies have a painful bite but beautiful eyes

There are many types of magnifying glasses, large and small, cheap and expensive.

A big magnifying glass could save your life if you have no matches to start a fire. If you really like magnifying glasses then maybe your parents might get you a microscope someday. Always remain curious. Look at everything closer, and keep asking: What? How? Why?

Gallery of some of my local plankton

Ed Ward, USA

These photomicrographs were taken with 30 year old American Optical/Reichert Microstar or Diastar microscopes (aka model 410 or 420), which are good values on the used market in the US. Some tricks of illumination used; a simple 3.2 Mp USB2 microscope camera with ToupView software captured the images.

bar is about 1 mm

Head end of *Chaoborus sp.,* phantom midge larva from Mississippi River, 4X objective, polar + darkfield, stitch of 4

One of the joys of plankton is occasionally capturing a fierce predator. This one was netted in Red Wing, MN on 7 March 2023. Several times each winter I catch a *Chaoborus*. Midges are small flies with aquatic larvae and pupae. The about 10 mm long larva of this midge is transparent apart the comma shaped air bladders. The false colors are from polar filters, highlighting muscles. Being mostly invisible it can wait for an unsuspecting water flea then suddenly extend its basket like mouthparts for prey capture in a blink of an eye (14 milliseconds).

bar is 0.2 mm

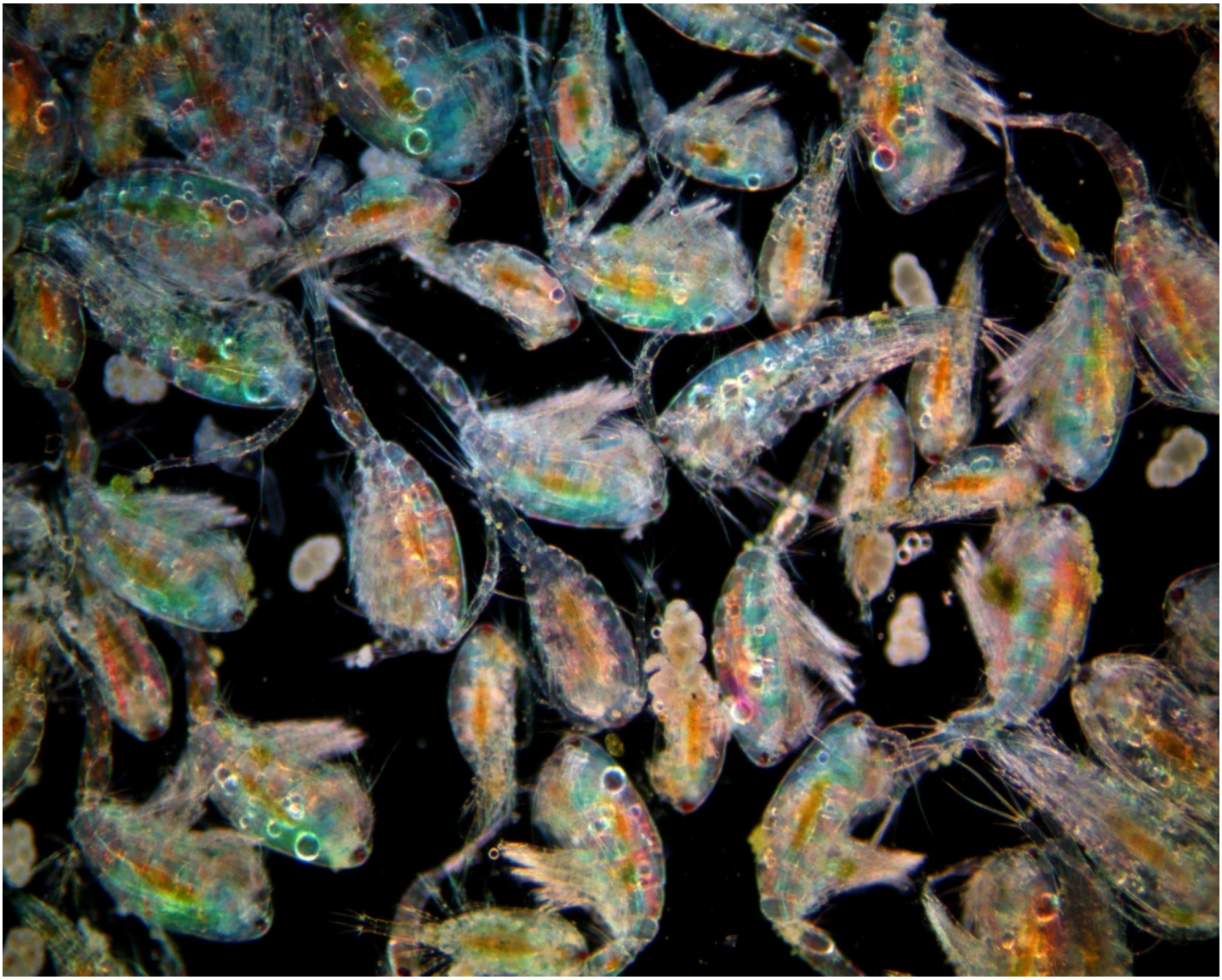
<u>Phytoplankton</u> cyanobacteria from Mississippi River, Red Wing, Minnesota, 10X objective, dark field

The river was having a bit of a blue green algae bloom on 23 August 2019. Most of these blooms are due to fertilizer runoff and although most are not toxic some are, somewhat unpredictably so. Blue green algae are not close relatives of true (eukaryotic) algae, but rather important kinds of bacteria (prokaryotes) that have been generating oxygen for over 2.5 billion years (the time of the great oxygenation event that precipitated vast deposits of iron ore in the northern part of my state, Minnesota, USA). *Prochlorococcus* is a tiny (0.6 micron) very abundant marine cyanobacteria that by itself produces 20% of all photosynthetic oxygen on earth.

Cyanobacteria are the base of many aquatic food chains. They both make sugar from sunlight and some can fix nitrogen in organic molecules. They do the latter with specialized heterocyst cells, seen as occasional clear vesicles in the straight strands of *Anabaena* above.

Many genera are present. "*Dolichospermum*" (spiral coils, now back in genus *Anabaena)*, may have been the first plankton discovered, by Antoni van Leeuwenhoek in 1674. See Micscape Feb 2016, The riddle of the 'green streaks,' In search of the first microorganism which Antoni van Leeuwenhoek described, by Wim van Egmond.

Much of bacterial taxonomy is chaos, but a guess at cyanobacterial genus can be reached by colony shape. My sample probably includes *Merismopedia* (at bottom, square rafts with subunits of 4 cells), *Microcystis* (the lumpy clumps), *Coelosphaerium* (near center, denser ball) and some "grass clippings" or flos-aquae of *Aphanizomenon* were seen elsewhere on the slide. A lot of variety was present in this particular bloom.

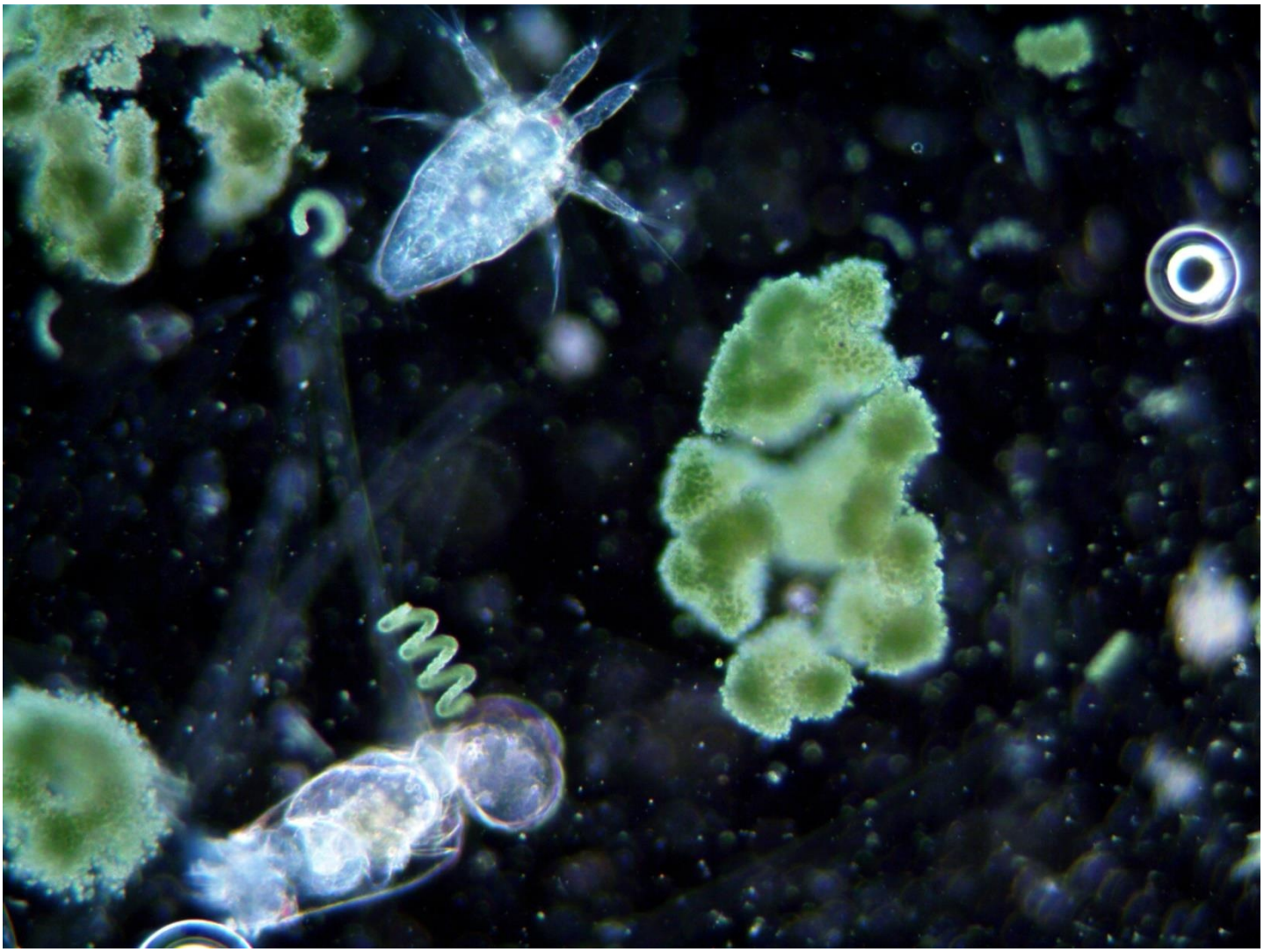


bar is 0.5 mm

<u>Zooplankton</u> netted from Pottery Pond, Red Wing, MN, packed with copepods, 4X objective, polar + dark field

Sometimes this pond yields mostly copepods, and other times mostly cladocerans (water fleas, often in midsummer), and occasionally rotifers are predominant. 1 Sept 2019 was a day for copepods, mostly cyclopoid, a few calanoid. The colors seen above are from polar filters, largely highlighting muscles.

In terms of numbers of individuals, copepods are probably the most abundant animal on earth. Most are about 1-2 mm long, barely visible to the naked eye, but are easily seen with even low power microscopes. Copepods occur in marine and freshwater, and swim by rowing with antennae on their heads. Most copepods have one eye (one common genus is *Cyclops*). Copepods are small enough for oxygen to diffuse around the body; *Cyclops* have no heart, but *Diaptomus* does. Most (pelagic calanoids, and cyclopoids, benthic harpacticoids) are free-living, but some copepods are parasitic on fish. Copepods produce eggs (some clusters are seen above) which go through 6 nauplius stages (a tiny 6 "legged" form using pairs of antennules, antennae, and mandibles for locomotion) and 5 copepodite stages to eventually become adults. Some other crustaceans including crabs, shrimp and barnacles also have nauplius larvae that look similar. Insects also commonly undergo metamorphosis. Crustaceans and insects are both arthropods, and recent evidence shows insects descended from crustaceans. As birds are dinosaurs, insects are crustaceans. The most successful kind of animal, crustaceans fill the water, land and air.

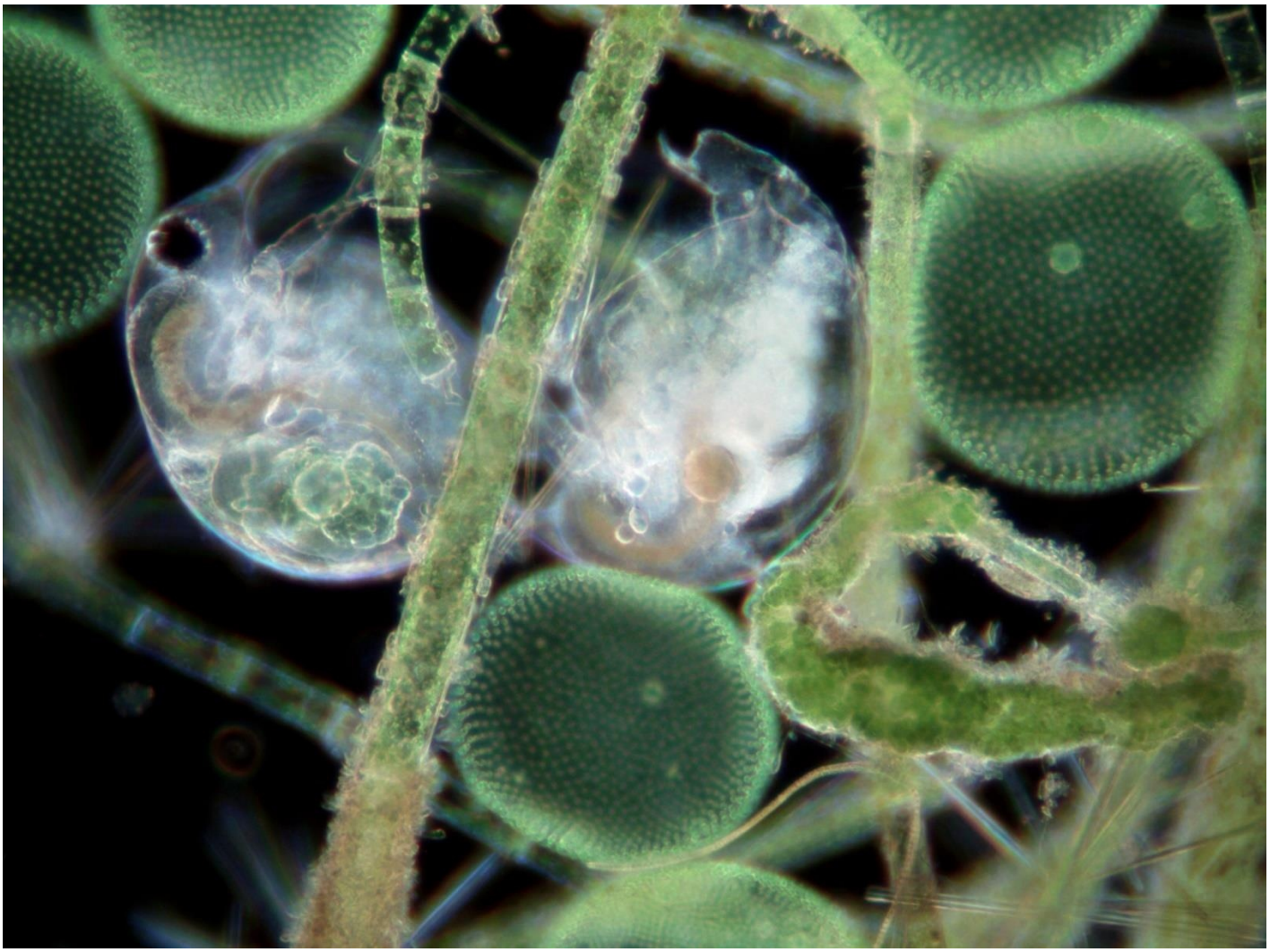


bar is 0.2 mm

Nauplius larva, *Brachionus* rotifer, cyanobacteria, Mississippi River, Red Wing, MN, 10X objective, dark field

The nauplius larva at top would have grown up to be a copepod if not eaten (or netted by me). Although only about 100 microns long, it is a complex animal with many thousands of cells organized into multiple complete systems of organs. It is a crustacean arthropod. That phylum of invertebrates with chitin exoskeletons and jointed legs also includes insects and spiders. Arthropods have a great body plan for small animals, and are wildly successful, compromising by far most species of animals. Arthropods also far outweigh all vertebrate animals put together in terms of carbon biomass. (See Bar-on *et al*, The biomass distribution on Earth, PNAS 2018 to be humbled by how insignificant yet destructive *H sapiens* is compared to the rest of life).

Lower left is *Brachionus*, also about 100 microns long. Rotifers are a phylum of mostly microscopic animals that van Leeuwenhoek named "wheel animalcules" because of the 2 whirling circles (corona) of cilia at the head end that bring food particles to the mouth (cilia are blurred above by fast motion). Rotifers have a simple body plan (stomach and gut but no anus, gizzard-like mastax, teeth-like trophi, no true body cavity) consisting of about 1000 total cells (the nauplius might have 4000 and you may have 100 trillion cells). The *Brachionus* above is a female holding her egg. She might have cloned herself asexually (parthenogenesis, the exclusive reproductive strategy of common bdelloid rotifers) but in some circumstances (including crowding) males are produced and sexual reproduction then can occur in *Brachionus* (a monogonontoid rotifer).



bar is 0.2 mm

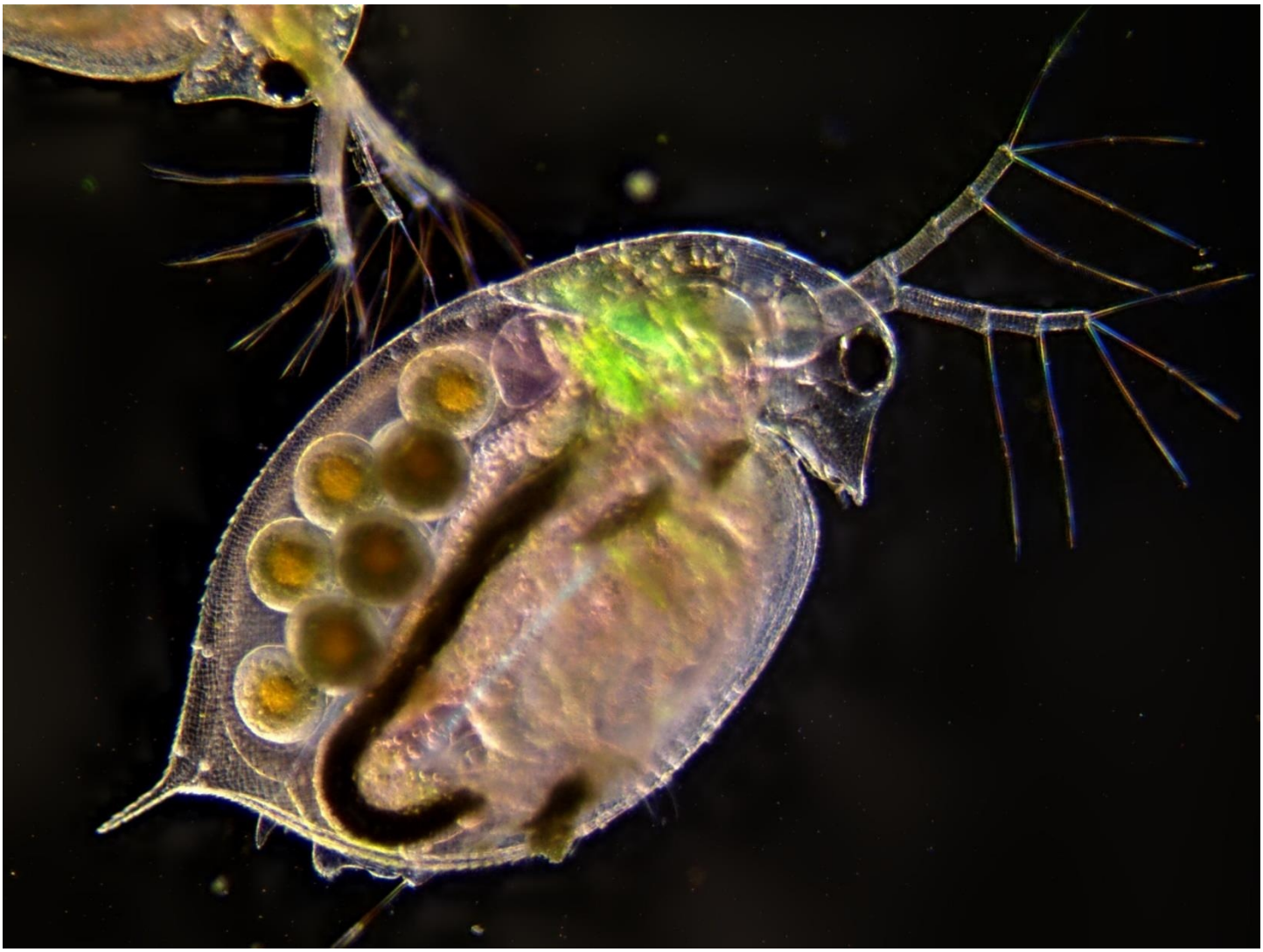
2 *Bosmina,* also *Volvox,* filamentous and diatom algae, Pottery Pond, Red Wing, MN, 10X objective, dark field

Netted 13 October 2018.The *Bosmina sp.* are cladocersans, tiny crustacean relatives of Daphnia and other "water fleas". The one on the left probably has a developing egg inside. Unlike copepods, the baby *Bosmina* will look like a miniature adult when it hatches.

The pretty green globes are *Volvox*, a colonial green alga. Each of its nearly 5000 cells has 2 whip-like flagella, so the colony can slowly, gracefully "roll" through the water seeking the right amount of sunlight. Inside some Volvox are much smaller green balls. These are daughter colonies that will be released when the parent colony dies.

Several thick vertical filaments can be seen to be made of individual box like cells with green chloroplasts inside; they are eukaryotic green algae. The clump to the right (covered with small brownish diatoms) might be a green algae or a blue green algae (aka cyanobacteria). The chloroplasts inside plants all started out as a cyanobacteria that was engulfed by a plant ancestor about 2.1 billion years ago, and perhaps a similar event happened later.

Diatoms are a special major group of algae that arose much later, in the Jurassic period. They have brownish chloroplasts and live in intricate glass (silica) houses. They are beautiful test subjects for high power microscope objectives. At this low power you can see some box shaped diatoms clinging to algae, a thin brown strand of tiny brown boxes just below the lower *Volvox*, and some out of focus larger rod like (pennate) diatoms at the bottom right. Oceans are full of plankton diatoms, which are responsible for about 20% or more of global photosynthesis.



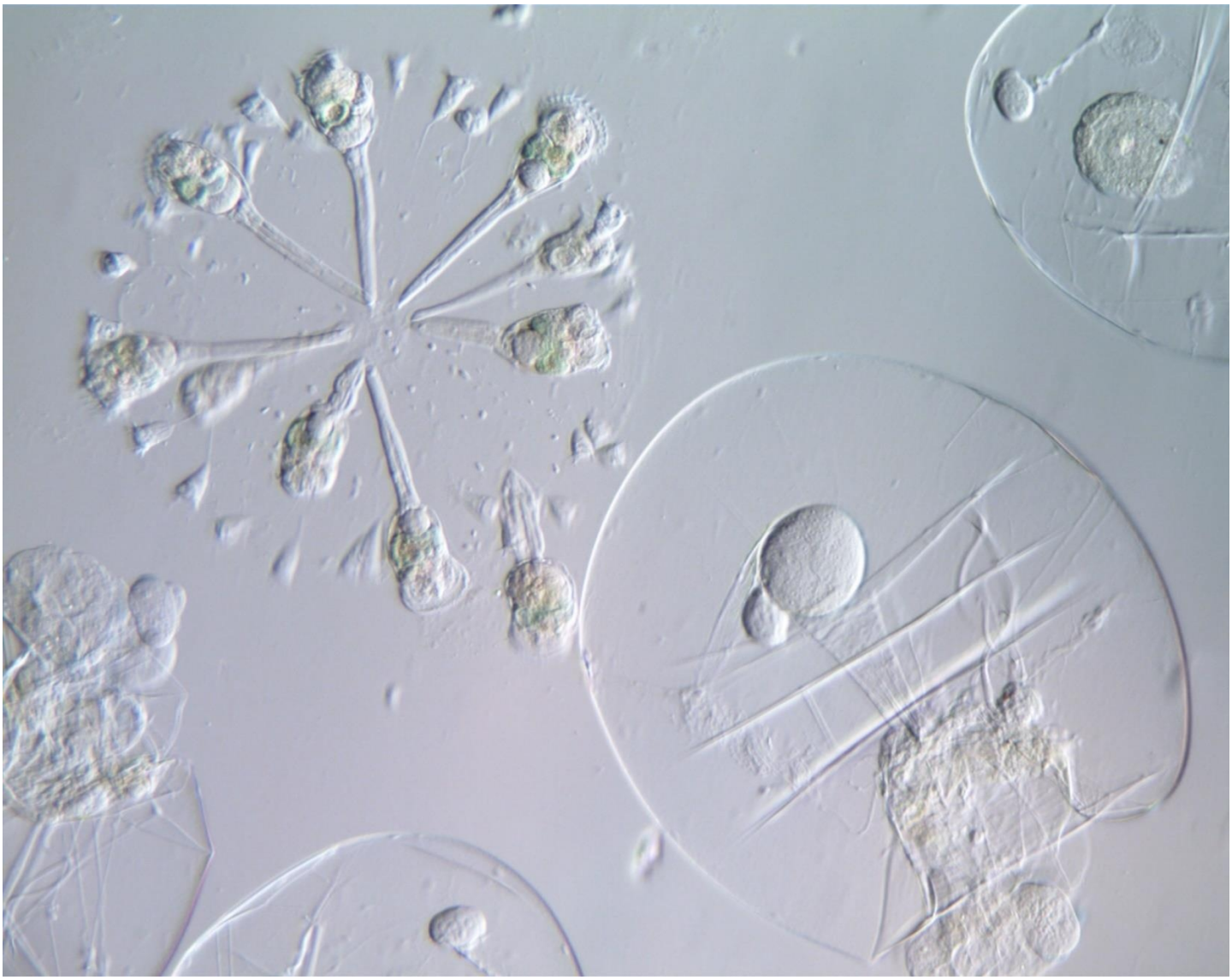
bar is 0.5 mm

Gravid *Daphnia* sp., Mississippi River backwaters, Red Wing, MN, 4x dark field + polar, stack of 2 images

Netted 19 May, 2019. Daphnia is the classic cladoceran water flea. Cladocera is one of the many orders of crustaceans; it is a very adaptable body plan that includes decapods (crabs, lobsters, etc), copepods, barnacles, krill, ampipods (sand fleas, scuds), ostracods (seed shrimp), isopods (wood lice).

Like copepods Daphnia uses antennae as "arms" to row itself jerkily through the water. This one is pregnant, with eggs along the inside of its back. It has two compound eyes and a simple eye, the ocellus at the base of the head (poorly seen above). The dark backwards J shape is its intestine full of food. Ventral to the gut it has gills it beats back and forth (not seen here). It also has a heart, the bag located just to the right of the top egg in this case.

Like other arthropods, cladorcera have an open circulation, i.e. a heart and circulatory fluid, but no blood vessels (a few have a short, pipe like aorta). Their clear blood, the hemolymph, does the functions of both blood and tissue fluid, sloshing around freely inside their body cavity. The heart helps keep it mixed, like a bucket of water with a submerged pump shooting water along the side. The hemolymph has a few colorless hemocytes which have simple immune functions (limited compared to your white blood cells). With dark field lighting you can often watch the hemocytes circulate in *Daphnia*. They are propelled upward by the heart and slowly trace a clockwise path around the periphery of the body before arriving back at the bottom of the heart for another go around.



bar is 0.2 mm

Conochilus unicornus, **a colonial rotifer, *Asplanchna sp*. predatory rotifer, peritrich ciliate epibionts, Pottery Pond, Red Wing, MN, 10X objective, oblique illumination, collected 16 August 2022.**

Oblique illumination can be good for seeing fine detail in transparent subjects.

I never know what I'll find in the local fishing pond. Because of rotting bait and other inputs it's usually eutrophic, containing excess nutrients. This increases plankton dramatically, which is good for my hobby. So far I've not seen "dead zone" die offs, but methane bubbles up in a few places that are probably anoxic (all the oxygen having been consumed by rotting processes). A few times I've found the colonial rotifer *Conochilus*, seen upper left. This colony was falling apart; full colonies have maybe 100 individuals and using their wheel like coronae the colony can spin and swim slowly. There are more vorticellid ciliate protozoa than rotifers in this sad colony. A lot of peritrichs are epibionts, hitching a ride on crustaceans or on the faint gelatinous structure of a rotifer colony.

Lower right is *Asplanchna*, which means "no internal organs" in Greek. Mostly empty, it has coronae, mouth (doubles as anus), mastax with trophi (gizzard), blind stomach, 4 cell proto-kidney, bladder, vitellarium (yolk sac), muscle and nerve fibers. The latter use serotonin signaling, so perhaps a depressed *Asplanchna* ("doctor, I feel so hollow") would respond to Prozac. *Asplanchna* is a transparent ambush predator on rotifers and cladocerans, and it might also eat algae. You sometimes see a miniature baby inside a mom, as *Asplanchna* gives live birth.

Vorticella conochili

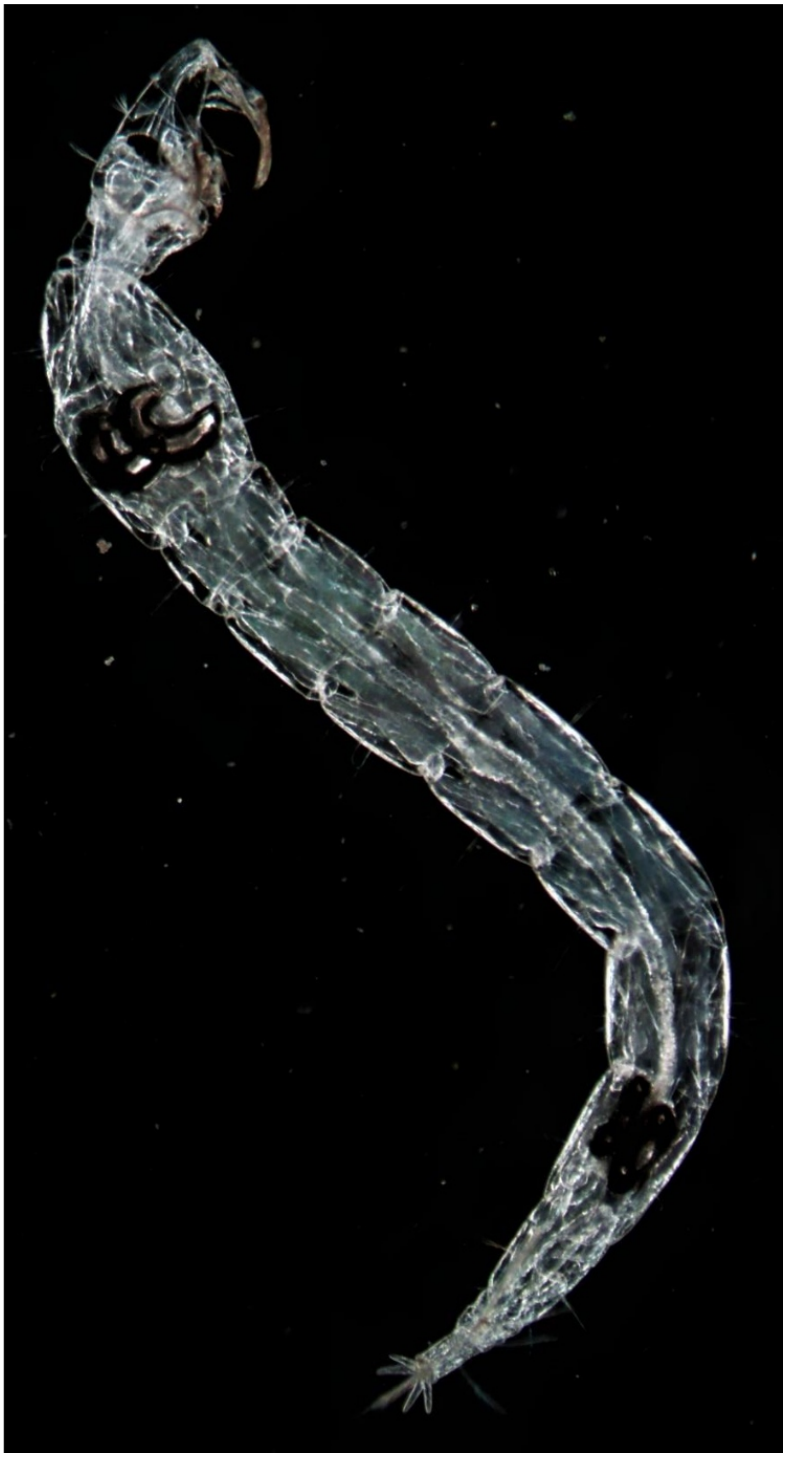
bar is 0.5 mm

Arrenurus sp. **mite "larva", copepods including some crowded with green epibionts, copepod nauplii, a cladoceran, Pottery Pond, Red Wing, MN, 4X objective, dark field + epi LED illumination, collected 8 September 2018**

Mites are a very diverse group of arthropods, part of Class Arachnida along with spiders, scorpions, daddy longlegs, horseshoe crabs and some others. Mites and ticks are 8 legged (as adults) ectoparasitic bloodsuckers and comprised Order Acari, but the taxonomy of these groups has been revised many times. The genus *Arrenurus* alone has over 950 species and it's thought about half of all water mite species are undiscovered. The *Arrenurus* above is blue with deep red eyes and sculpted armor that could have inspired a *Heavy Metal* comic book. Some other water mites are also very colorful, do elaborate mating dances and have big, strange lock-and-key genitals. Before you decide it would be great to find your own new mite species and name it after your favorite punk rock band, consider how specialized mites and the scientists who study them must be. *Arrenurus* has seven stages: egg, prelarva, larva, protonymph, deutonymph, tritonymph, and adult. I'm not sure what stage we're looking at above. Maybe it is a male, as *Arrenurus* means "male tail" in Greek, but detailed keys are nonexistent or behind paywalls.

Aquatic larvae of *Arrenurus* are ectoparasites on dragonfly or damselfly (or sometimes on fly or beetle) aquatic larva, and when the host crawls from the water and splits its skin to become a winged adult, the *Arrenurus* crawl onto the fresh adult and pierces its skin, creating a pocket underneath to suck on for nutrition. Free food and a ride; it's a pretty good deal for *Arrenurus*. We aren't sure how bad it sucks for the dragonfly to carry around dozens of tiny external mites. It's in the parasites' interest to keep the hosts alive, but some are heavily infested.

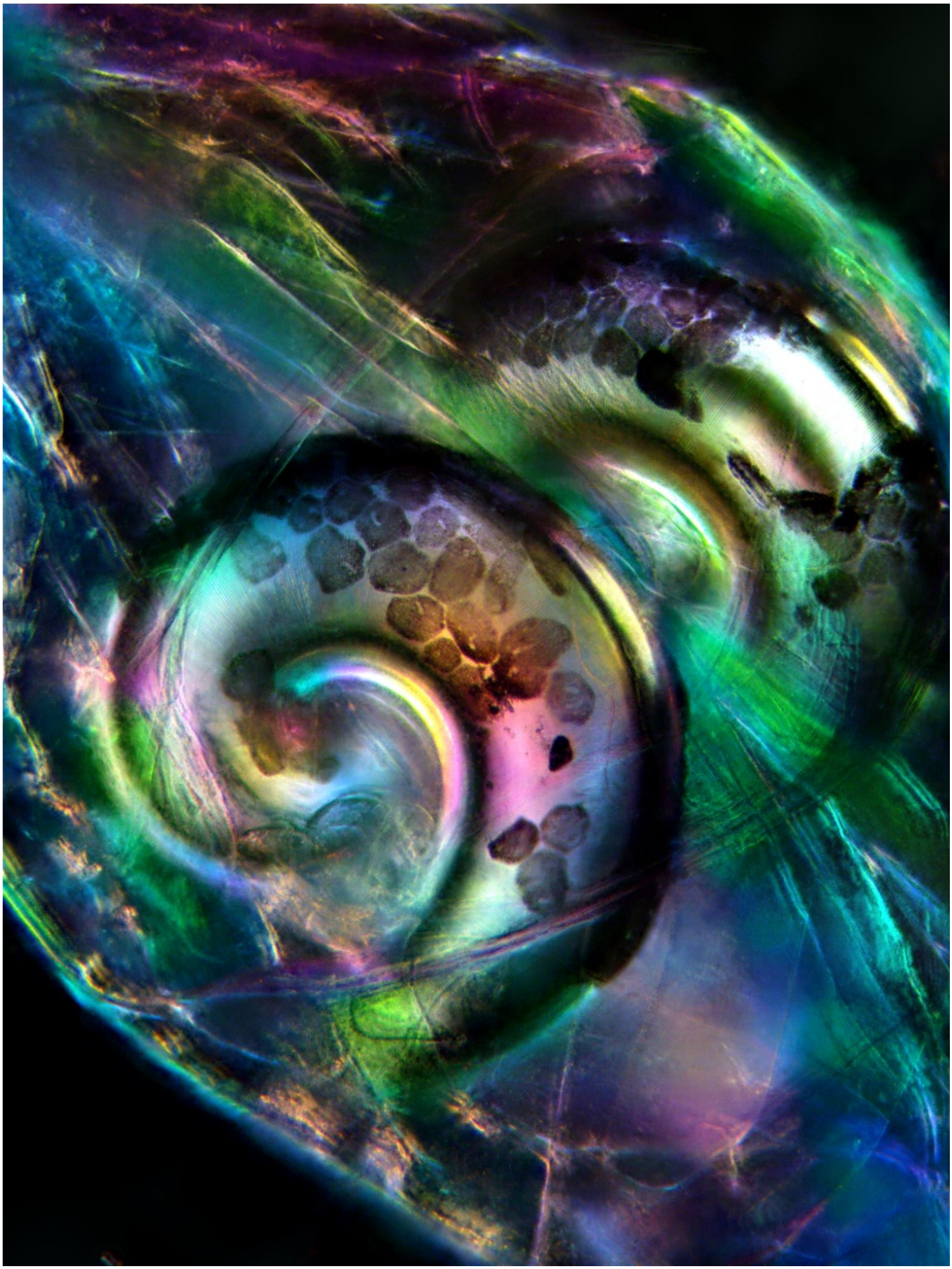
In the background are multiple other kinds of aquatic arthropods. Creepy crawlies rule the seas and the land.



Above left *Chaoborus sp.,* phantom midge larva **Above right, *Chaoborus* pupa**
4X objective, stitch of about 10 each, dark field, with added LED epi on right, specimens about 10-12 mm long

Netted from Mississippi River on 3 Jan 2020 and 21 Dec 2019

I'm always happy when I see the faint flicking motion of a transparent *Chaoborus* larva in my collection jar. Midges are important in food chains. Small fish eat trillions of midge larva in lakes and ponds, and they are also sold as fish food ("blood worms"). Lake Malawi in East Africa has so many *Chaoborus* that the millions of flies look like smoke as they arise *en mass* from their pupae. The flies are collected, compressed and eaten as nutritious "kunga cakes". Famous explorer David Livingstone claimed they taste like caviar!



bar is 0.4 mm

Chaoborus **larva, showing anterior air bladders, 10X objective, crossed polars + retarder, 29 April 2022**

***Micscape* online magazine** has many resources to help you learn more about plankton, including:

The Micscape Pond Life Identification Kit includes many planktonic algae, protists and arthropods

The Micropolitan Museum by Wim van Egmond has many gorgeous plankton photomicrographs

Life in Thin Air by William H Amos 2001 describes Darwin's discovery of aeroplankton

Salute the Plankton by Cheryl Gilpin appeared in Micscape Magazine in 2008

Plankton themed stamps- a selection, compiled by David Walker appeared in 2018

David Walker, Howard Webb, Richard Hovey, Howard Lazerson and many others have described the nets, travel microscopes and other equipment they use in their plankton studies

---

In grateful remembrance of Walter Dioni

You can learn much more about how to use microscopes and about the living things you'll find in natural bodies of water by looking through back issues of *Micscape*. About a decade ago I started using microscopes as an adult hobby. At first I looked mostly at commercially prepared permanent slides. They are easy to use, but became somewhat boring. But once I discovered pond water there was the possibility of a new discovery every day. Soon after, I found plain bright field illumination seemed inadequate for most plankton, so I was prompted to learn dark field, oblique and other lighting techniques.

I was especially inspired and educated in these endeavors by the late Walter Dioni's more than 60 *Micscape* articles. Senor Dioni was working with a simple Chinese microscope and everyday household supplies. He discovered many good at home microscopy techniques, such as using clear nail polish to make permanent slides. Walter loved rotifers, and explored tree holes and many other waters around his town in Mexico for microscopic life. The articles by Walter Dioni are now archived by *Micscape*, and are a treasure to this day.

I have received much joy from reading *Micscape* over the years, but started contributing just this year. I was such a rank amateur 10 years ago that I hesitated to send a message to the well accomplished Mr. Dioni. I started an email to Mr. Dioni in 2014 letting him know how helpful his articles had been, but I never sent it. Soon after, Walter became sick and died. Cherish the good people you know.

Ed Ward, comments welcomed, email – eward1897 AT gmail DOT com

Published in the April 2023 edition of *Micscape* Magazine

www.micscape.com