Gastrotrich swimming between algal filaments, collected from the wild, River Teifi (Olympus BH-2 microscope with microflash)

Filming the invisible!

The natural world comes in all shapes and sizes – and wildlife cinematographer IAWF member **Sinclair Stammers** has spent much of his worklife focusing in on the very smallest elements, from insects and tiny parasites, right down to bacteria and crystals. Sinclair describes how his interest in parasitology and specialism in microscopy have led to a fascinating and varied career, which has encompassed not only scientific research on a microscopic level but also some visionary art projects as well as more mainstream wildlife filming adventures.

All photos: Sinclair Stammers

> I feel very privileged to have been working as a cameraman and photographer during this incredible period of technological development.

A fascination with the microscopic world started for me at an early age, so when an advertisement for a job as a scientific photographer based in the Biology department at Imperial College appeared in the 'British Journal of Photography' in 1978, I jumped at it. My background interest and education was in natural science, including biology and geology A levels, followed by a 3-year HND course in Creative Photography at the London College of Printing. These subjects had prepared me well for my later employment. So, after organising my portfolio, I turned up for interview and, to my amazement, they offered me the job. Even better, I soon discovered that the department specialised in parasitology, a special interest of mine.

Working from a cupboard

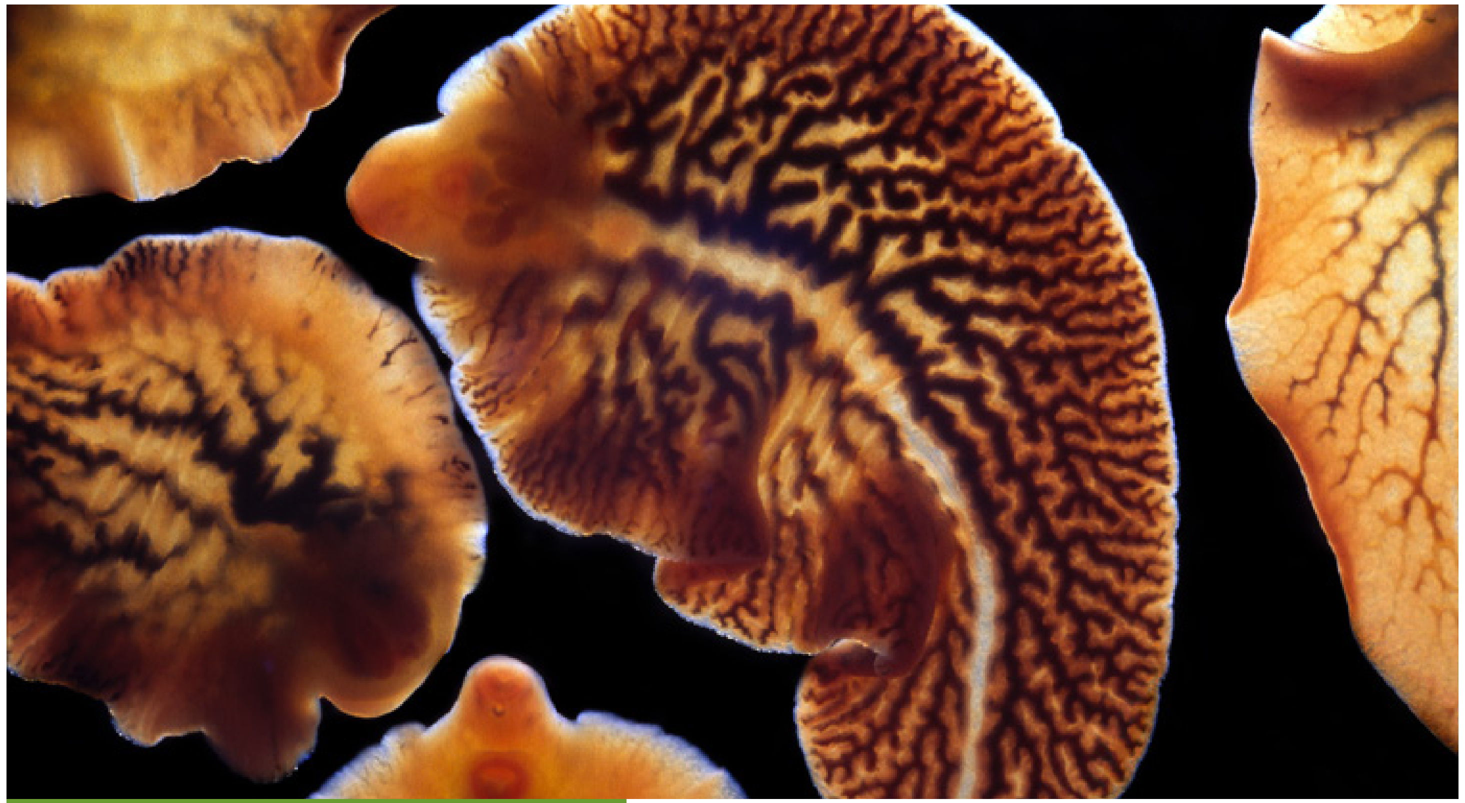
After taking up the position, I was shown a small studio and darkroom in the basement, which housed an unassuming equipment cupboard, but with a nice surprise inside: a superb collection of Nikon equipment including specialist close-up lenses. This was the start of a 17-year full-time career in a busy centre of scientific excellence. It also happened to be the year my daughter Melissa was born, so the future felt very exciting.

A regular stream of people would visit my tiny studio with a dizzying array of photographic challenges. This was long before the arrival of digital imaging; luckily, there was a superb colour processing lab, Ceta, just around the corner in Queensgate Mews, which handled all the E-6 (colour reversal or slide) processing, ensuring high-quality results.

Some excellent microscopes were made available to me, including a Zeiss photomicroscope, also interestingly stationed in a cupboard! This was a fine instrument with which to practice and learn the basic skills of the microscopist, and I spent many happy hours peering through the eyepieces.

I started as a stills photographer but after a while became interested in capturing the moving image as well, so invested in a secondhand 16mm camera. The beauty of this camera was that it could run off a mains electricity supply and it wasn't long before it was set up on the trinocular head of a microscope. I was then able to shoot 16mm footage of microscopic parasites. These early setups were primitive by today's standards as the technology has advanced beyond our wildest dreams – and with current video technology the images just keep getting better and better.


Sinclair setting up a four-camera shoot timelapse of tissue cultured mast cells at Glaxo Smith Kline, Stevenage


Dark field macro photograph of liver fluke (*Fasciola hepatica*), backlit to show the treelike pattern of the gut engorged with blood

An early prototype HD camera in the 1990s designed for use by surgeons, bolted onto my microscope as an experiment at Sony Professional Solutions Europe, Basingstoke

The technology and my kit evolves

Over the decades, the video technology 'arms race', which started with 16mm cine film telecined in a video facility, moved onto the standard definition analogue video formats such as U-matic, Betacam SP and Digital Betacam, then the HD formats of the 1990s/2000s, and finally today's state-of-the-art digital formats such as 4K and 6K, has been coupled with huge improvements in microscope optics, resulting in a series of quantum leaps and enabling the current gorgeously detailed imagery.

In parallel with the developments in video capture technology, the range of microscope options has broadened enormously from the original optical or light microscopes.[1] A standard compound microscope has a limit of 2000x magnification, this being dictated by the wavelength of light, hence the need for the development of electron microscopes, which can go to much higher magnifications and operate at shorter wavelengths than visible light. A scanning electron microscope[2] has approximately 400 times the depth of field of a light microscope and a hugely increased magnification range. The transmission electron microscope[3] goes even beyond this, and is now a vital tool in life sciences research, able to resolve organelles (subunits of cells) and fine ultrastructure within the interior of cells at very high magnifications. Confocal[4] and fluorescence[5] microscopy are also hugely important developments in analytical and diagnostic imaging, and are now used routinely in the modern laboratory.

> Over the years I have put together a comprehensive kit of microscopes, macro systems, endoscopes and straitscopes, coupled with the best cameras available. The natural world in all its glory deserves this no compromise approach and with luck it is possible to produce imagery that is both scientifically accurate and aesthetically nerve-tingling.

I feel very privileged to have been working as a cameraman and photographer during this incredible period of technological development. Keeping in mind how I could harness this amazing technology to enable my personal work as an image-maker and artist, over the years I have put together a comprehensive kit of microscopes, macro systems, endoscopes and straitscopes, coupled with the best cameras available. The natural world in all its glory deserves this no compromise approach and with luck it is possible to produce imagery that is both scientifically accurate and aesthetically nerve-tingling.

I have customised my microscope system to be portable but also capable of generating high-quality imagery. It all fits snugly into a large SAM Case silver equipment box, which can be transported around the world on wheels. The benefit of having it all together in one box is that it is all properly organised in one place and the plan apochromat objectives, eyepieces, photographic eyepieces, micro zoom lenses, light sources and microscope body are all safely protected. After a flight to Chicago to film a BBC documentary *The Witness was a Fly* with GTC member Gavin Thurston, the box was severely dented by the airline – but at least the optics were safe.

Over time, I have added new modular bits of kit to this system, an important addition being a motorised microscope stage, the research and development for which took about a year. This enables the cameraperson/microscopist to glide smoothly in the microscopic domain, following and tracking swimming microorganisms and small animals in a controlled way. Combine this with micro-zoom optics that fit precisely between the microscope and camera, and it is possible to produce a 'helicopter shot' on a microscopic level!

I have a number of these highly specialised micro zooms, such as a Wild M40 and Leitz Vario. They all have their different technical requirements; some are just right for the tiny sensor of a Blackmagic pocket camera or, at the other extreme, others will cover a large 35mm image sensor such as the Sony α7SII. Another huge benefit of some modern cameras is the ability to film in very low light levels. Recently, I filmed bioluminescence in the marine dinoflagellate *Pyrocystis fusiformis*. The camera of choice was the Sony α7SII as the ISO can be raised to a staggering 409,600. The sensor is unbelievably sensitive and produces a rich full-colour image.

Emerging from the cupboard

Back to the journey of my career: although I was employed full-time by the Biology department, I was allowed to do private work in my own time (British universities are very generous in this respect). I picked up an exciting commission from musician Brian Eno's production company, Opal. The brief was to create an ambient video called *Crystals*, which involved filming crystal growth through a microscope. It lasted about an hour and was edited to Brian Eno's haunting ambient music. The film stock was Fuji colour negative and the processed camera master was telecined to 1-inch C-format magnetic tape. The edit was done by a brilliant video editor, Arthur Johnsen at VTR in Soho. Of course, this being the 1980s, it was before the arrival of nonlinear editing, so this was a highly innovative and expensive operation, resulting in one of the world's first ambient videos.

Encouraged by this diversion from my scientific work at the University, I then had the good fortune to meet John Sparks, at the time head of the BBC Natural History Unit (NHU), at a seminar in South Kensington about sound recording. I introduced myself and he gave me his business card and invited me to visit the NHU in Bristol. This was the start of a collaboration that has continued over the years right up until *Blue Planet II*. Other NHU productions with which I have been involved have included: *Life in the Undergrowth*, *Incredible Journeys*, *Darwin's Tree of Life* and *The Truth about Fertility*, to name but a few.

Andean adventure

In 1995, I left the Biology department, feeling I'd been there long enough and aching for a change. I had been invited by Richard Brock (one of the original producer/directors of

Footnotes

1 The optical or light microscope, is a type of microscope that commonly uses visible light and a system of lenses to magnify images of small objects. Optical microscopes are the oldest design of microscope and were possibly invented in their present compound form in the 17th century (https://en.wikipedia.org/wiki/Optical_microscope).

2 A scanning electron microscope (SEM) produces images of a sample by scanning the surface with a focused beam of electrons. The electrons interact with atoms in the sample, producing signals that contain information about the surface topography and composition of the sample (https://en.wikipedia.org/wiki/Scanning_electron_microscope).

3 Transmission electron microscopy (TEM) is a microscopy technique in which a beam of electrons is transmitted through a specimen to form an image. The specimen is most often an ultrathin section less than 100nm thick or a suspension on a grid. An image is formed from the interaction of the electrons with the sample as the beam is transmitted through the specimen (https://en.wikipedia.org/wiki/Transmission_electron_microscopy).

4 Confocal microscopy is an optical imaging technique for increasing optical resolution and contrast of a micrograph by using a spatial pinhole to block out-of-focus light in image formation. Capturing multiple two-dimensional images at different depths in a sample enables the reconstruction of three-dimensional structures (known as optical sectioning) within an object (https://en.wikipedia.org/wiki/Confocal_microscopy).

5 A fluorescence microscope is an optical microscope that uses fluorescence and phosphorescence instead of, or in addition to, scattering, reflection and attenuation or absorption, to study the properties of organic or inorganic substances (https://en.wikipedia.org/wiki/Fluorescence_microscope).

Collecting the larvae of *Simulium damnosum* in Ghana

Life on Earth) to organise an expedition to film the mountain tapir in remote locations in Ecuador and Colombia. Within months of leaving Imperial, I was on a plane to Quito with a budget of $10k to cover costs, to meet a mammal expert, Dr Craig Downer, who had been conducting fieldwork using radio collars to track the movement of these elusive animals. In Quito, the South American Explorers Club became my research and planning base. I was lucky enough to meet a young American, George Frasier III, who had just bought a Land Rover – and then, another day, I came across a paper at the Club on how to launch an expedition in remote parts of the Andes, written by Shane McCarthy, who had a lot of experience on how to survive in hostile Andean environments – perfect! I invited him to join the trip and our team was complete.

Our destination would be an area called La Playa, a high altitude wilderness area near the summit of Mount Sangay, one of the last strongholds of the very rare mountain tapir (*Tapirus pinchaque*), known locally as La Danta de Monte. The team set off from Quito early one morning and headed south on the rough road to the furthest village, Aloh, where we met our guides, whom Craig knew from previous expeditions. Mount Sangay is a stratovolcano and the most active volcano in Ecuador. Our team of guides and porters numbered 12 people and two mules, which meant transporting a lot of food for 10 days in the field! This team trudged for about 50km into the wilderness area carrying heavy packs of camera equipment and my trusty Ronford Baker tripod, until eventually we reached a basecamp of thatched huts. On the way up to the La Playa area, we passed the graves of two BBC cameramen, who had died after being hit by falling ejecta from the volcano. Sangay is famous for chucking out massive boulders the size of houses, which explode on impact with the ground, spraying the area with high-velocity shrapnel. As we progressed, our guides would point out the mountain tapirs, often appearing as nothing more than tiny black dots surrounded by pampas grass. I had never worked at such high altitudes before; the climb was exhausting and without the help of the guides, filming would have been impossible – they were all strong men of iron.

I recall the chief guide, Roberto Cass, standing on a ridge calling me up. I was carrying the preloaded Bolex with 400ft magazine on my back. As I ran up the slope, I slipped and slid backwards upside down on basalt gravel for a good 10m. Dusting myself off, I resumed my climb to the top of the ridge, where the tripod was already in position, ready for the camera. Before I had time to think, I became aware of a mountain tapir close by in the valley below. I filmed it running in front of a low cliff. It is a majestic animal, the size of a Shetland pony, covered in black shaggy fur, with a long prehensile snout, big ears tipped with white fur and white lips (the "Al Jolson look", as Craig quipped).

The conditions on the mountain were quite tough; we all got sunburnt through our clothes as the effects of ultraviolet are a lot more powerful at these high altitudes of 3800m above sea level. However, we were rewarded with some of the first decent footage of the mountain tapir in the wild.

Reptilian monsters

Fast forward a few years to 2000, and I was part of an expedition to visit the Panacocha biological reserve, in the heart of remote Amazon rainforest. My travelling companions this time were herpetologist Dr Morley Read, mycologist Professor Ted Tuddenham and writer Chandra Masoliver. This trip would be notable for an incredible animal encounter. The buildup was that, after camping in the forest, we had paddled along a creek back to the main camp, to find that as we arrived people were shouting that there was a giant snake swimming in the lagoon. We grabbed our stuff, jumped into two dugout canoes and set off for the other side of the lake. On the way, the side of an enormous fish, presumably an arapaima, surfaced near to our canoes. Ted said it looked like the Loch Ness monster! We continued to where the snake had been spotted, thinking it would probably be long gone.

A parasitic nematode (*Nippostrongylus brasiliensis*)

Photomicrograph of aspirin crystals illuminated with polarised light to reveal the birefringent colours (Leitz Ortholux II Vario-Orthomat microscope)

But as we arrived at a tangle of roots near the lake margin, there it was, an enormous anaconda. Its girth was massive and we estimated a body length of 10–12m. It seemed to take forever to glide slowly over the tree roots culminating in a thick stump of a tail. We followed it to a shallow pond, where our minder, Hannibal, pulled out his Glock 9mm, saying he was terrified the snake might attack and drag one of us into the water. Meanwhile, Morley had climbed out of the canoe and was standing on a small island. When an enormous head loomed into view in the dark water at his feet, he famously cried out "F*ck, it's a big one!". Amid much hyperventilating, he fell backwards into the canoe. Needless to say, all of this was caught on our cameras.

Also on the theme of snakes, after my return from the Ecuador trip, I immediately cracked on with building an interesting installation to be displayed in a gallery at the Natural History Museum. The exhibition was called the 'Nature of History' and had been conceived and funded by London-based Arts Catalyst, with substantial grants from telecoms company AT&T. Simon Robertshaw from Liverpool Art College and I shared a huge gallery to set up our artwork. My installation was in two parts: firstly my microscope was housed in a beautifully made bespoke wood and glass cabinet with samples placed under the microscope in a Petri dish containing a self-sustaining miniature ecosystem, consisting of microscopic nematode worms called *Caenorhabditis elegans* feeding on a lawn of bacteria (*Escherichia coli*). Professor Mark Blaxter from the Biology department at Imperial had assisted with this. A video camera connected to the microscope sent pictures to a powerful data projector mounted in the roof of the gallery, which projected the live image onto a huge white plastic sheet glued to the floor. The result was astounding as the worms were magnified to the size of anacondas, writhing and slithering across the floor, much to the delight of children. My second installation was a video projection of a cow decomposing in timelapse, which I had filmed in Shropshire a month earlier. The exhibition was a great success and seen by about 70,000 people over the 6-week period. It is worthy of note that *Caenorhabditis elegans* was the original laboratory organism to have its DNA sequenced and mapped by Dr Sidney Brenner, which helped to pave the way for the human genome project a few years later.

Parasites: a lifelong interest

Another important commission came along in 2013, when I was invited to make a 15-minute film about the 'Lifecycle of the Liver Fluke', by the veterinary pharmaceutical company Merial (now under a new name). This idea appealed because of my past history at Imperial College. Back in the mid-1980s, an eminent parasitologist Professor JD Smyth had done a lot of work on the liver fluke, producing wonderful ink drawings of its complex lifecycle in collaboration with medical artist Nicky Barrett, which had been published in a classic textbook about parasites. This was a huge opportunity to film this important parasite with the latest in video and microscope technology. So, we set up the equipment in a lab in the Forest of Dean, where we systematically worked through the stages of the lifecycle. The Head of Technical Services at Merial at the time was Andy Forbes, who wrote an excellent script, which was then narrated in a recording studio by broadcaster and veterinarian, Mark Evans. It ended up as a short and elegant description of a very nasty disease that affects both humans and farm animals.

Blood-sucking flies have also been a speciality of mine. The World Health Organization commissioned me to visit the Noguchi Research Institute in Ghana, the focus of interest being the insect vectors that transmit African river blindness (or onchocerciasis). The fly in question is *Simulium damnosum*, a very small biting blackfly. While drawing its blood meal from a human host, microscopic nematode worms (*Onchocerca volvulus*) are released into the bloodstream of that host. To make a comprehensive record of its lifecycle, I visited remote villages where African river blindness is a common and persistent problem. It struck me as quite strange when I had

African blackfly (*Simulium damnosum*) showing its upturned tarsal claws (top) and blood feeding on a human host, Ghana (bottom)

a group of men sitting on benches dangling their legs next to a river to attract the flies. Sure enough, the flies arrived and started biting, offering up great close-ups of the 3mm-long flies 'cut and sponge' feeding on the skin of the men. These pictures revealed an interesting detail that when the flies bite they upturn the tarsal claws on the first pair of legs in order to avoid alerting the host to their presence. Concerned, I asked the scientists if it was ethical to encourage people to be bitten. The response was that these people are bitten routinely and inevitably – and at least in this case they were being paid, for which they were grateful, and that perhaps this research would contribute to a solution to the problem.

There was more research into blood-sucking insects back in the UK, including a collaboration with the Institute for Virus Research at Pirbright, which supplied me with biting midges (*Culicoides nubeculosus*). I managed to persuade some of my mates from the pub to be willing victims for the price of a few pints. The starving midges were placed on the soft skin of the forearm, which had been taped to a bench to keep the arm very still; because the camera is filming at x2 magnification, even the slightest movement can spoil the shot.

On another occasion, at the Liverpool School of Hygiene and Tropical Medicine, we filmed the African Tampan tick. This is a large, most unpleasant-looking tick, with a voracious appetite for human blood. This time I managed to persuade a burly rugby-playing student to be a volunteer. I think he'd consumed a few too many beers at lunchtime in order to summon up some Dutch courage, so was in a jolly mood when I placed a starved African Tampan tick (*Ornithodoros moubata*) onto his arm, again taped down to the bench. At first the tick resembled a dried cornflake, but as it dug its mouthparts deeper into his flesh, it fattened up to the size of a large grape, all the time producing pools of excreted liquid plasma. The student started to sweat profusely and rock uncontrollably on his seat, begging me to take the thing off him. Of course, I instantly obliged, but the next day his hand had swollen to the size of a football. Although this is not very nice, it was incredibly useful to record the biting behaviour to obtain important information about this ectoparasite. It has been estimated that a cubic metre of earth in a typical Kenyan mud hut harbours hundreds of these ticks; imagine the horror of them emerging at night to feed on the blood of children.

> The destruction of the world's fragile ecosystems for commercial and political gain is a terrible legacy that future generations will never forgive... Without the microscope providing a window into these invisible worlds it would be hard to convince people of their very existence.

Macro photograph of African Tampan tick (*Ornithodoros moubata*) engorged with human blood

Recent work

2018 was a bumper year: I joined a few expeditionary cruises, organised by SeaTrek Bali, on which my friend Dr George Beccaloni is the ship's resident naturalist. We travelled around the exotic Raja Ampat islands filming coral reefs in a wooden sailing ship called the Ombak Putih. Raja Ampat is a major epicentre of marine biodiversity and this area is one of the last surviving areas of pristine corals in the world. We saw the world's largest bivalve, the giant clam, and the biggest terrestrial arthropod, the coconut crab, but our main reason for being there was to film and record George telling the story, based on current research, of Alfred Russel Wallace, the Victorian scientist and contemporary of Charles Darwin. George is an authority on Wallace and it was a pleasure to record the story in the actual locations Wallace had visited, such as the village of Dodinga where he experienced a eureka moment, induced by a fit of malarial fever. This delirium-induced inspiration resulted in an essay on the theory of evolution by natural selection, which was then sent together with a famous accompanying letter to Charles Darwin.

Recently I have also been working on cataloguing fossil trilobites with experts Pete Lawrance and Dr Bob Kennedy. This has resulted in the co-authoring of two books: 'Trilobites of the World' and 'Trilobites of the British Isles', published by SIRI Scientific Press. These are great examples of the flexibility and diversity of scientific photography. It has been an enormous pleasure to visit collections and museums all over the UK to see and handle the very best of the world's most popular extinct arthropods.

Preserving our natural world

Filming through the microscope has been an enduring passion through the many twists and turns in my admittedly peculiar career. My studio, situated in a converted woollen mill on the banks of the River Teifi in Newcastle Emlyn, as well as the extensive collection of specialist equipment housed within, is in a constant state of readiness for the next challenge. Nearby, there is a steady supply of interesting microorganisms to be found, and I am also enjoying a wildflower meadow planted a few years ago in my back garden – already a diverse range of critters are moving in.

On my mind is the concern over human-induced mass extinction, and the impending disaster of climate change. Without sounding overdramatic, the destruction of the world's fragile ecosystems for commercial and political gain is a terrible legacy that future generations will never forgive. My grandsons are growing up into an impoverished world, where seeing and experiencing wildness is an increasing rarity. So much of our lives is dominated, and indeed controlled, by the existence of microorganisms, such as the oxygen in our atmosphere or the bacteria living in the microbiome of the human gut. Without the microscope providing a window into these invisible worlds it would be hard to convince people of their very existence.

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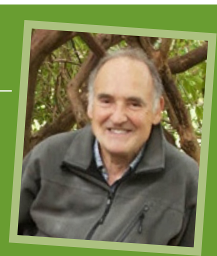

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You can see examples of Sinclair's microscopy and macro work at:
https://vimeo.com/320613983

and a short extract from the SeaTrek Bali expeditionary cruises:
https://youtu.be/0KZPSpUytUA