**Prof. Joseph T. Y. Wong Research Interests**

**Liquid Crystalline Chromosomes, including DNA damage responses**
These dinoflagellates Liquid Crystalline Chromosomes (LCCs) encode some of the largest-known eukaryotic genomes (up to 80 times human genome size) but counter-intuitively had no detectable nucleosomes and have the lowest known chromosomal protein-to-DNA ratios. In the absence of architectural nucleosomes, as in sperm nuclei, condensin SMC4 subunit knockdown led to decondensation, implicating a larger role of the chromatic ATPase in LCC architecture (Yan et al., 2020).

Biophysical evidence suggested highly anisotropic organization, manifested as strong birefringence when observed under polarizing light (see figure; Chow et al., 2010: *Eukaryot. Cell*). Their histone-like proteins (dHLps), which bear no relationship with core histones (Wong et al., 2003) organized DNAs in a concentration-dependent manner, including looping of DNAs (Chan et al., 2007). Architectural organization of LCCs will be of general interests in understanding how highly condensed genome-sized DNAs can have accessibility, modularity, and reversibility. Dinomitosis occurs without nuclear envelope breakdown nor direct attachment to the extranuclear spindles, which in other systems would have activated the spindle checkpoint. Dino-replication progresses without global LCC decondensation, which would not have initiated S phase in other eukaryotes. These are special attributes that likely incur special Genome Damage Checkpoint controls, as well as DNA Damage Responsive pathways (DDRPs). Our transcriptome analysis suggested most eukaryotic DDRPs are expressed during normal cell cycle (Li and Wong 2019), likely related to transcription-replication im-coordination of the tandem repeat arrays (TRAs). In addition to high copies numbers in unidirectional TRAs, which constitute the major gene-encoding protocol, LCC chromo-genomics likely modulate the DDRs towards supercoiling revisited, not incoincident with the major dHLP role in nucleoid DDRs and the roles of recombination.

Potential Applications: Generation of small genome-size dinoflagellates for synthetic biology.

**Cellulosic Thecal Plates: Crystallinity, Modularity and Coordination** Synthesis of cellulose (CS), the most abundant biopolymer on earth, is not fully understood despite intensive research in the last 20 years. Dinoflagellate cells constitute simple systems that cell cycle and life-cycle orchestration of CS can be investigated in synchronized cell cohorts (Kwok and Wong, 2003, 2010). Thecate dinoflagellates are well known in their ability to produce intricate cellulosic thecal plates (CTPs), which are intracellular and three-dimensional, contrast with extracellular and two-dimensional nature of plant cell wall. CTPs, deposited in (See figure) exact arrangements that are seconded as taxonomic characters, have the hardness of wood (Lau et al., 2007). We are interested in the mechanism leading to biodeposition of CTPs and its potential biotechnological application. Knockdown of a dinoflagellate cellulose synthase led to severe malformation of CTP and impediment of life-cycle transitions (Chan et al., 2019; *Front. Microbiol.*), which are important in HAB dynamics and bleached coral regenerations.
**Cellular growth and genome duplication cycles**

Cell volume is generally regarded as coordination between cellular growth rate and genome cycle progression. Commonly regarded to be doubled, cellular growth endpoints with non-quantized ranges, with dependency of changing environmental resource availability. Cellular cellulose, lipid and volumes increased non-stochastically with genome cycle progression, reflecting coordination with growth at late G1 (Kwok and Wong, 2003,2005. In protists, patchy resource utilization founded variations from the binary fission (BF) scheme, reminescence of the oocyte-early embryonic development, endowing cellular growth prior to genome division cycles. In the photo (16 of the 32 nuclei are in focus), a MF cell grown to 32 times ($2^5$) prior to five consecutive S-M.

The major cellular biomasses are constituted by membranes, but how membrane deposition is orchestrated in well-ordered manner is not well understood. Using genetic, biochemical, imaging and molecular approaches, we identified the Ca$^{2+}$ signalling pathway coupling growth rates, BF-MF switching, and cortical Ca$^{2+}$ stores (Lam et al., 2005; Yeung et al., 2006). The metabolic rate dependent cyclic ADP-ribose transients, a key Ca$^{2+}$ secondary messenger, was a key switch between binary versus multiple fission (MF) (Lam et al., 2009,). The project is continuing with key components identified through subtraction cloning between MF/BF cells.

Potential Applications: but have both applied and biological applications, affecting buoyancy (or sinking), cell harvesting, and secondary processing.

**Dinoflagellates**, a major unicellular group (>2000 species), are a significant group of plankton and the intracellular symbiotic microalgae (zooxanthellae) of corals (and many other invertebrates), as well as major causative agents of harmful algal blooms (HABs) and shellfish poisoning syndromes. Dinoflagellates are famous for producing large repertoires of bioactive compounds, including many toxins and polyunsaturated fatty acids. Recent development in genomics and transgenesis make it strategic to consider the group as a new frontier for molecular biotechnology and synthetic biology. Dinoflagellate photosynthetic pigment peridinin-Chla complex is a major model for the study of photobiology, whereas their bioluminescences are seen in vast sea surface. Their chloroplast genomes are reduced to “minicircles”, small plasmid-like circular DNAs (Leung and Wong. 2007) with single gene encoding of 16-20 photosynthetic genes.

**Selected references**


Yan, KHT, Ng, JCN, Kwok, ACM, and Wong, JTY (2020) Knockdown of dinoflagellate condensin CcSMC4 subunit led to S-phase impediment and decompaction of liquid crystalline chromosomes. *Microorganism*


