

單選題 (共 50 題, 每題 2 分, 答錯倒扣 0.5 分)

(\*注意: 請於試卷上「選擇題作答區」內依序作答。)

#### Article 1

Food allergy is an abnormal immunological response or allergic reaction that occurs when certain foods are consumed. It is considered a major public health concern, affecting 1–2% of adults and 3–6% of children living in developed countries. A survey conducted in 2013 by the Centers for Disease Control and Prevention, revealed that the number of children allergic to certain foods increased by 50% between 1997 and 2011. Besides, over 150 million Europeans suffer from food allergy and it is speculated that an astounding 44% of adults living in Britain have at least one form of allergy or the other, growing by around 2 million from 2008 to 2009 alone. Generally, over 170 foods can provoke allergenic reactions, but 90% of incidences are believed to be caused by allergenic proteins present in milk, egg, soy, crustacean/shellfish, fish, tree nut, peanut, and wheat, but a large number of potentially allergenic individuals are unaware of their allergic reactions to certain foods until after consumption. Typically, clinical symptoms include respiratory issues, skin reactions, cardiovascular disorders and problems with the gastrointestinal (GI) tract. Meanwhile, clinical manifestations associated with non-IgE-mediated food allergies include food protein induced enterocolitis (FPIES), weight depreciation, proctocolitis syndrome, pulmonary hemosiderosis and celiac disease. Other symptoms of food allergy includes the life threatening anaphylaxis, with a detailed epidemiological survey conducted in the united states revealing that annually, about 125000 cases of emergency and 53700 cases of anaphylaxis is caused by food allergies, leading to hospitalization of 2000 patients and in acute cases, 200 deaths. Unfortunately, the current best practice to prevent food allergy is to avoid consumption of allergenic foods.

The characteristic nature of antigenic proteins is basically glycoproteins with molecular masses of 10–70 kDa, which contain protein sites called epitopes. These epitopes are recognizable and interact with allergen receptors based on their three-dimensional conformation. Considering their molecular configuration and structure, any process that induces changes in protein conformation can also affect structural features of epitopes, thereby influencing antibody binding ability. In fact, some treatments such as heating induce formation of new allergenic compounds, otherwise called neo-allergens via interactions among constituents.

With the developments of nonthermal processing techniques, such as pulsed light, high pressure processing (HPP), irradiation, cold plasma, ultrasound and pulsed electric field(PEF), it is possible that nonthermal processing techniques can also induce changes in protein conformation and mitigate the allergenicity of certain proteins, while retaining the original characteristics of the food materials. Therefore, researchers have explored the impact of non-heat based processing technologies on allergenic proteins and the possibility of producing hypoallergenic foods using such approaches.

1. The allergenic reaction is usually cause by which food component? (A) lipid (B) Carbohydrate (C) Protein (D) Amino acid (E) trans-fat
2. Which of the following may not be a common clinical symptom of food allergy? (A) hypersomnia (B) rhinitis (C) hypotension (D) vomiting (E) abdominal pain
3. What is the best practice to prevent food allergy? (A) take medicine (B) consume functional food (C) not eat allergenic food (D) be a vegetarian (E) wash hand often.
4. What is epitops? (A) glycolipids (B) oiligosaccharides (C) protein (D) amino acid (E) nucleoid.
5. Which of the following is not a non-thermal processing method? (A) pulsed electric field (B) Ozone (C) high pressure processing (D) microwave (E) ultrasound processing

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**Article 2****(Source: Early Human Development (2015)91:629-635)**

Breast milk is an extremely complex and highly variable biofluid that has evolved over millennia to nourish infants and protect them from disease whilst their own immune system matures. The composition of human breast milk changes in response to many factors, matching the infant's requirements according to its age and other characteristics. Therefore, the composition of breast milk is widely believed to be specifically tailored by each mother to precisely reflect the requirements of her infant. The many antimicrobial and immunomodulatory components of breast milk are suggested to compensate for the deficiencies in the neonatal immune system, and impair the translocation of infectious pathogens across the gastrointestinal tract. In addition, breastfed infants are also known to possess a more stable and less diverse intestinal microbiota than formula-fed infants, but possess more than twice the number of bacterial cells. This may be partially due to alterations at the level of the gut mucosa due to bioactive substances in human milk.

Demonstrating the bioactivity of breast milk, a study on shed epithelial cells in the faeces of infants has shown that gene expression in the neonatal gastrointestinal tract is influenced by breastfeeding, with differential expression found between formula-fed and breast-fed infants in genes regulating intestinal cell proliferation, differentiation and barrier function. Breast milk contains bioactive factors that are capable of inhibiting inflammation, as well as enhancing specific-antibody production.

Additionally, pattern-recognition receptors, which are crucial factors in the recognition of microorganisms in the neonatal respiratory tract and gut, are present in breast milk. Factors such as the Toll-like receptors (TLR-2 and TLR-4) provide efficient microbial recognition, working in synergy with the co-receptor CD14 and soluble CD14, which are found in high quantities in breast milk. Further regulation by soluble toll-like receptor 2 (sTLR-2), which regulates cell activation via cell surface TLR-2, has also been noted in breast milk but not in infant formula. Similarly, an as-yet unnamed 80 kDA protein identified in breast milk appears to inhibit TLR-2-mediated but activates TLR-4-mediated transcriptional responses in human intestinal epithelial and mononuclear cells. Reduced TLR-2 responsiveness at birth has been proposed to facilitate the normal establishment of beneficial microbiota such as bifidobacteria. Various studies have examined the influences of maternal characteristics on breast milk composition. Important factors known to influence breast milk composition, such as the gradual increase in fat concentrations throughout a feed, have well-defined effects. However, other potential influences, such as the mode of delivery and maternal BMI, have less high-quality evidence supporting their role. The difficulties in accurately assessing the composition of breast milk (e.g. sampling time) hinder efforts to elucidate the true value of these effects. Furthermore, there is a profound lack of knowledge regarding how alterations in breast milk composition may subsequently impact infant and later health outcomes.

6. Which one of the following does not properly describe breast milk? (A) change over lactating stage (B) complex biofluid (C) contain microorganisms (D) the composition is same among different lactating mothers (E) defense infant from infectious pathogens.
7. Breast-fed infants are better protected from pathogenic microorganism not because of (A) better intestinal barrier function (B) anti-inflammation activity of bioactive factors (C) higher anti-body production (D) higher vitamin concentration (E) beneficial bacteria in breast milk.
8. TLR-2, TLR-4 and CD14 is not a (A) protein (B) receptor (C) lipid (D) microorganism recognizer (E) facilitator of normal microbiota establishment.
9. Which one of the following probiotic might present in breastmilk? (A) Escherichia coli (B) Bifidobacterium bifidum (C) Lactobacillus paracasei (D) Lactobacillus casei (E) Lactobacillus acidophilus.
10. What would significantly influence the composition of breastmilk? (A) hair color (B) maternal BMI (C) financial status (D) educational degree (E) mood.

## Article 3

(Source: J Agric Food Chem (2018) DOI:10.1021/acs.jafc.8b05982)

trans-Resveratrol has beneficial effects on colorectal cancer, through its antioxidant capacity, and its roles in regulating eicosanoid synthesis. This study determines how changes in resveratrol structure affected its biological activities. Our results showed that trans- and cis-resveratrol and hydroxylated analogs (piceatannol) (10–25  $\mu\text{M}$ ) displayed similar antioxidant activities (2–3 fold higher than trolox) and inhibit eicosanoid synthesis and Caco-2 growth ( $76.5 \pm 2.7\%$ ,  $48.2 \pm 3.1\%$  and  $41.1 \pm 2.3\%$ ,  $p \leq 0.05$ ). These effects can be related with an increase of the percentage of cells in the S phase ( $156.3 \pm 5.6$ ,  $91.2 \pm 3.3$  and  $64.1 \pm 2.8$ ,  $p \leq 0.05$ ) as a consequence of the impairment of the cells in G0/G1. Furthermore, we observed that these molecules induce apoptosis at 100  $\mu\text{M}$  ( $48.2 \pm 6.6\%$ ,  $p \leq 0.05$ ;  $4.3 \pm 2.5\%$  and  $21.2 \pm 3.3\%$ ,  $p \leq 0.05$ ). These actions were related with changes of the mitochondrial membrane potential involved in the intrinsic pathway of apoptosis. However, methoxylated (pterostilbene, pinostilbene, trans-trimethoxy-resveratrol, and CAY10616) (0.1–10  $\mu\text{M}$ ) and halogenated (PDM11, CAY10464, PDM2, and CAY465) (1–10  $\mu\text{M}$ ) stilbenes inhibited Caco-2 cell growth, with a higher potency than resveratrol (50% inhibition at 0.1–1  $\mu\text{M}$ ) but without effects on oxidative stress and arachidonic acid cascade. Thus, our results show that the antioxidant effect of hydroxyl stilbenes is related to eicosanoid synthesis regulation and the basic stilbene structure of two benzene rings bonded through a central ethylene, is responsible for its effects on Caco-2 cell growth/DNA synthesis/cell cycle independently of redox state/eicosanoid synthesis modulation.

11. What is the theme of this article? (A) resveratrol structure affected its biological activities (B) curcumin structure affected its biological activities (C) EGCG structure affected its biological activities (D) genistein structure affected its biological activities
12. According to this article, what kind of cancer cells used in this study? (A) HepG2 (B) MCF7 (C) Caco-2 (D) COLON 205
13. This compounds could inhibit cell growth through (A) apoptosis (B) necrosis (C) autophagy (D) necroptosis
14. Piceatannol has antioxidant activity which is related to (A) fatty acid synthesis (B) amino acid synthesis (C) RNA synthesis (D) eicosanoids synthesis regulation
15. What kind of mechanism could poly an important role in pinostilbene induces cell death? (A) change of the mitochondrial membrane potential (B) change of protein synthesis (C) change of RNA synthesis (D) change of fatty acid synthesis

## Article 4

(Source: Food Function (2017) 8:2865-2574)

Inflammatory bowel diseases (IBDs), including Crohn's disease (CD) and ulcerative colitis (UC), are prevalent and debilitating health problems worldwide. Many types of drugs are used to treat IBDs, but they exhibit adverse effects such as vomiting, nausea, abdominal pain, diarrhea, etc. In order to overcome the limitations of current therapeutic drugs, scientists have searched for functional foods from natural resources. In this study, we investigated the anti-colitic effects of Wasabia japonica extract in a DSS-induced colitis model. Wasabi japonica is a plant of the Brassicaceae family that has recently been reported to exhibit properties of detoxification, anti-inflammation, and induction of apoptosis in cancer cells. In this study, we generated wasabi ethanol extract (WK) and assessed its anti-colitic effect. In addition, in order to improve delivery of the extract to the colon, WK was coated with 5% Eudragit S100 (WKE), after which the anti-colitic effects of WKE were assessed. In conclusion, WK prevented development of colitis through inhibition of the NF- $\kappa$ B signaling pathway and recovery of epithelial tight junctions. In addition, the anti-colitic effect of WK was enhanced by improving its delivery to the colon by coating the WK with Eudragit S100. Therefore, we suggest that wasabi can be used as a new functional food to prevent IBDs due to its anti-colitic effect.

16. What is the main purpose of this article? (1) to study the anti-cancer activity (2) to investigate the induction of apoptosis (3) to investigate the anti-colitic effect (4) to study the detoxification

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17. In this study, what kind of plant was used? (1) wasabi (2) ginger (3) shallot (4) garlic
18. Which one of the following compound might induce colitis? (1) ethanol (2) DSS (3) methanol (4) Eugragit S100
19. In order to improve delivery of the extract to the colon, the extract was coated with (1) DSS (2) Eudragit S100 (3) ethanol (4) methanol
20. According to this article, this functional food could prevent IBDs via (1) inhibiting the NFkB signaling pathway (2) inducing apoptosis (3) inducing cell cycle arrest (4) inhibiting vomiting

#### Article 5

(Source: Food Science & Nutrition(2019) DOI:10.1002/fsn3.932)

The fruit of *Siraitia grosvenorii* Swingle, Lo Han Kuo (LHK), contains a mixture of curcubitane-type triterpene saponins, known as mogrosides. A mogroside is composed of several glycosylated sugar moieties which form  $\beta$ -linkages with mogrols. *S. grosvenorii* fruit is widely used in Traditional Chinese medicine and was regarded as nontoxic GRAS sweetener. Its functions include moisturizing lungs and soothing coughs, reducing blood pressure, and preventing constipation. An immobilized enzyme system for bioconversion of Lo Han Kuo (LHK) mogrosides was established.  $\beta$ -Glucosidase which was covalently immobilized onto the glass spheres exhibited a significant bioconversion efficiency from pNPG to pnitrophenol over other carriers. Optimum operational pH and temperature were determined to be pH 4 and 30°C. Results of storage stability test demonstrated that the glass sphere enzyme immobilization system was capable of sustaining more than 80% residual activity until 50 days and operation reusability was confirmed for at least 10 cycles. The Michaelis constant ( $K_m$ ) of the system was determined to be 0.33 mM. The kinetic parameters, rate constant ( $K$ ) at which Mogrosides conversion were determined, the  $\tau_{50}$  in which 50% of mogroside V deglycosylation /mogroside III E production was reached, and the  $\tau$  complete of complete mogroside V deglycosylation/ mogroside III E production, were 0.044/0.017 min<sup>-1</sup>, 15.6 ± 1.55/41.1 min, 60/120 min, respectively. Formation of the intermediates contributed to the kinetic differences between mogroside V deglycosylation and mogroside III E formation.

21. In this study, what kind of fruit was used? (A) *Ganoderma formosanum*, (B) *Siraitia grosvenorii*, (C) *Ananas comosus*, (D) *Lentinus edodes*.
22. In this study, what kind of product was the authors looking for? (A) Intracellular polysaccharide, (B) Lo Han Kuo meat, (C) mogroside, (D) Culture medium.
23. Which step is NOT included for LHK application? (A) Reducing body fat, (B) moisturizing lungs, (C) soothing coughs, (D) reducing blood pressure, and preventing constipation.
24. What's the residual activity until 50 days of operation? (A) 8.00%, (B) 8.06%, (C) 80.0%, (D) 8,000 unit/g.
25. The authors also evaluated the enzyme activity of (A)  $\alpha$ -amylase, (B)  $\beta$ -glucoisomerase, (C)  $\beta$ -galactosidase, (D)  $\beta$ -glucosidase, in this study.
26. Which factor is not included for kinetic parameters analysis in this study? (A) Michaelis constant, (B) rate constant, (C) turnover rate, (D)  $\tau$  complete.
27. What's the meaning of ± 1.55 in this study? (A) Production yield, (B) standard deviation, (C) concentration, (D) control number.
28. What's the full name of GRAS? (A) Generally recognized as safe, (B) generally recognized as not safe, (C) generally considered as safe, (D) good and recognized as safe.
29. Which one is NOT discussed in this abstract? (A)  $\beta$ -glucosidase, (B) Lo Han Kuo, (C) reusability, (D) evaluation of cost.
30. What's the main purpose of this study? (A) to study the appearance of *Siraitia grosvenorii*, (B) to investigate the bioconversion of mogroside by immobilized  $\beta$ -glucosidase (C) to investigate the influence of production cost on Lo Han Kuo, (D) to raise fund from foreigners.

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**Article 6****Product Safety and Quality Dominate Innovation Awards****(Source: Food Technology (2018) Volume 72, No.9.)**

IFT18 innovation award winners showcase a unique packaging film, natural antioxidant and surrogate bacteria that can enhance food safety, product quality and shelf life. Advancements to food safety and product quality grabbed the top honors in the IFT18 Food Expo Innovation Awards competition, which culminated with the public announcement and presentation of the awards to Handary S.A., Kancor Ingredients Ltd., and Novolyze.

**Antimicrobial Film**

Handary S.A. captured the 2018 IFT Food Expo Innovation Award for its Antipack™ active antifungal biodegradable film, which can prevent mold growth by gradually releasing fermented sugar activities from the film onto the surface of solid foods such as semi and hard cheeses and dried sausages during their shelf life. The biodegradable and recyclable film utilizes an advanced controlled-released technology to combine poly lactic acid (PLA), fermented sugars, food cultures and fungal chitosan.

PLA is produced by the polymerization of lactic acid from sugarcane, while the fermented sugar is made from corn sugar fermented with food cultures *Lactobacillus paracasei* and *Propionibacterium freudenreichii* subsp. *shermanii*. Fungal chitosan is produced from the oyster mushroom and is water-soluble with a pH of 3.5.

Most molds require the presence of considerable moisture for growth. The controlled-released technology utilizes this moisture (relative humidity) to manage the migration of fermented sugar from the film onto the solid food surface. In addition, regulating the blending ratio of PLA and water-soluble chitosan-containing antifungal probiotics and adjusting the hydrophobic properties of fungal chitosan helps to control the migration rates of fermented sugar from the film onto a food surface.

The 90% transparent film can extend the shelf of life of products, and has a minimal effect on the taste, flavor, or color of foods. It has good heat-sealing properties and hot tack (max. 160°C) in automatic packaging.

**Natural Antioxidant**

Kancor Ingredients Ltd. was honored for its OxiKan CL - natural antioxidant solution. The rosemary-based ingredient can extend the shelf life of a variety of products without imparting color, flavor or aroma—even at dosages up to 400 ppm. Available in water-soluble and oil-soluble versions, the natural liquid extract is well suited for products that are sensitive to aroma, color and flavor, such as specialty fats, omega-3 fortified products, popcorn, and beverages.

In a comparative study on the shelf-life enhancement and oxidative stability of popcorn, OxiKan CL was tested against a natural tocopherol and a synthetic TBHQ. The study was conducted using two different dosages of OxiKan CL in canola oil. One dosage of the natural antioxidant was at the same level as the other antioxidants, while the other dosage was at a significantly lower level. OxiKan CL successfully outperformed natural tocopherol at a fraction of its dosage. It also demonstrated increased effectiveness in enhancing the shelf life of sensitive foods by outperforming TBHQ in popcorn stability.

Another study looked at the color impact of rosemary extract and OxiKan CL in medium chain triglyceride oil. Rosemary extract had a significant impact on the color of the oil at standard recommended dosage levels of 200 ppm, while OxiKan CL had no visible impact at the same dosage level as well as double the dosage level.

**Convenient Surrogate Bacteria**

Novolyze garnered the 2018 IFT Food Expo Innovation Award for its SurroNov® dried, ready-to-use surrogate bacteria, which are harmless microorganisms that mimic the inactivation of foodborne pathogens such as *Salmonella*, *Listeria* and *E. coli* under different kinds of stress. Due to their safety, the surrogates can be used directly at the processing plant or pilot scale to test the efficacy of microbial kill steps and intervention steps such as extrusion, pasteurization, drying, and roasting.

The convenient powdered product does not require any further enrichment before being inoculated. It is available in large quantities and initial concentrations of up to 10-log CFU/g, allowing users to inoculate up to several tons of food matrix while reaching high target inoculation levels. This is especially beneficial for testing continuous, high-throughput processes.

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In a study of a dry cat kibbles product (moisture 4.15%, aw 0.473), the SurroNov® surrogate bacteria was evaluated for thermal inactivation versus *Salmonella*. The first step was to rehydrate the kibbles to achieve a targeted level of moisture content of 15% and a water activity of 0.85. Thermal death dynamics of the tested surrogate products and a mixture of four different *Salmonella* serotypes were estimated after product inoculation using a dry heater apparatus at three temperatures (80°C, 90°C and 100°C).

The surrogate bacteria showed a greater thermal resistance than the *Salmonella* cocktail for each tested temperature. D-values confirmed that the surrogate bacteria had a higher decimal reduction time than *Salmonella*. Thus, the analysis verified the appropriateness of the SurroNov® product for process validation as a surrogate microorganism versus *Salmonella* in the tested conditions.

31. What is the theme of this article? (A) a food fraud report (B) a food advertisement (C) an announcement of awards competition (D) a judging criteria of food safety and product shelf life.
32. According to this article, why the packaging film can prevent mold growth on the surface of solid foods? (A) It produces PLA and more. (B) PLA and chitosan are the antimicrobial agents. (C) It consumes sugar on the surface of foods. (D) It has combined effects of the moisture and antimicrobial substances.
33. What is the source of chitosan used in the film? (A) oyster (B) fungus (C) sugarcane (D) food cultures.
34. The word "hydrophobic" is closest in meaning to (1) immiscible in water (2) immiscible in oil (3) zwitterion (4) amphiphilic.
35. What is the source of antioxidant in OxiKan CL? (A) popcorn (B) medium chain triglyceride oil (C) rosemary (D) tocopherol.
36. What is "TBHQ"? (A) an antioxidant (B) a natural flavor agent (C) a rosemary extract (D) natural tocopherol.
37. Which is NOT property of OxiKan CL? (A) an antioxidant (B) a flavor agent (C) dissolved in water (D) dissolved in oil.
38. The word "Surrogate" is closest in meaning to (A) outlier (B) regulator (C) pasteurizer (D) substitute.
39. Which is NOT benefit of SurroNov®? (A) It is harmless. (B) It mimics the activities of *Listeria*. (C) Its thermal resistance is higher than the *Salmonella*. (D) It is a powdered product.
40. What is the major function of SurroNov®? (A) It is a tool for the validation process of sterilization. (B) It controls the growth of foodborne pathogens. (C) It is a food additive in cat foods. (D) It is a pathogen.

#### Article 7

(The following paragraph was adapted from Hellmuth et al. *Mol. Nutr. Food. Res.* (2019) 63:1700889)

Women who enter pregnancy with a raised BMI are significantly more likely to have obese offspring, giving rise to an intergenerational cycle of obesity risk. The conventional paradigm posits that individual susceptibility for, and inter-generational transmission of, obesity is largely attributable to genetic makeup. However, currently identified genetic variants account for only a modest proportion of variation in BMI.

Meanwhile, a rapidly growing and convergent body of evidence in humans and animals suggests that the origins of obesity can be traced, in part, to the intrauterine period of life, at which time the developing fetus responds to "sub-optimal" conditions by producing structural and functional changes in cells, tissues, and organ systems (i.e., the concept of fetal programming). While the mechanisms for early programming of human metabolism and obesity risk are yet to be fully elucidated, recent advances in the "omics" technologies facilitate a deeper insight to this process. Metabolomics provides potential to analyze the biological effects of genetic and environmental factors, since metabolites are the downstream product of biochemical pathways, and thus, closely related to the phenotype of interest. Previous studies have utilized metabolomics to investigate various pre and postnatal programming mechanisms, but are lacking in standardization or statistical power. Consistently, maternal omega-3 (n-3) fatty acid status, but not dietary n-3 fatty acid intake, has been found to be protective against offspring obesity risk.

However, most of these studies used infant or childhood BMI as an outcome and, thus, the influence of the intrauterine environment cannot be separated from obesity-related postnatal factors. To date, no human study has prospectively

investigated the association between maternal metabolomic profiles during pregnancy with newborn adiposity. The primary aim of the present study was to examine—using an unbiased approach—the prospective association between key plasma metabolites representative of maternal lipid and energy metabolism in early, mid, and late gestation and newborn adiposity in a longitudinal, prospective birth cohort at the University of California, Irvine (UCI). Dual-energy X-ray absorptiometry (DXA) whole body imaging was used to directly quantify newborn body composition (percent fat mass) rather than relying on commonly used weight- and length-based proxy measures of infant adiposity (e.g., weight-for-length ratio). The second aim was to identify maternal determinants of variation in the specific metabolites that predict newborn adiposity in this cohort.

41. What is the aim of this research? (A) To study the relationship between maternal genetic and infant obesity. (B) To investigate the correlation of “body-for-length ratio” in mothers and infants. (C) To identify the potential lipid metabolites biomarkers in maternal gestation and in the infants. (D) To study the n-3 fatty acid metabolism in mothers and in infants.
42. What does the meaning of fetal programming in this article? (A) The obesity may be originated from fetus. (B) The obesity may be originated from neonatal stage. (C) The obesity may be originated from newborn stage. (D) The obesity may be originated from preconception stage.
43. What does the meaning of “suboptimal” condition in this article? (A) Excellent (B) Ideal (C) Trivial (D) Limited.
44. Regards to the metabolomics analysis in this article, which of the following description is correct? (A) It can provide the gene expression data. (B) It can predict biochemical pathways. (C) It can distinguish the n-3 fatty acid originated from mother or from diet. (D) It can predict the percentage of fat content.
45. What is a longitudinal cohort study? (A) It is a study focused on the same subjects repeatedly over a period of time (B) It is a study focused on the living area and environment in subject over a period of time. (C) It is also called prevalence study. (D) It is also called case-control studies.

#### Article 8

(Source: Liti, G. eLife DOI: 10.7554/eLife.05835.003)

Humans have exploited the budding yeast, *Saccharomyces cerevisiae*, for over ten thousand years for brewing and baking. This close connection with human activity led Louis Pasteur to discover its essential role in alcoholic fermentation in 1857. Brewing was also the key motivation for the start of yeast genetics. The initial breeding experiments by Ojvind Winge at the Carlsberg laboratory in the 1930s aimed to combine desirable brewing traits by crossing different strains. Our ability to control and manipulate its life cycle has made the budding yeast the most powerful, single-cell eukaryotic system for biological research, and it was rapidly adopted around the world to investigate virtually every aspect of biology. Early on in *S. cerevisiae* research, the scientific community adopted a single reference isolate, the S288c strain, or strains derived from it. This reference strain was obtained by crossing several parental strains and has the peculiar trait that it can be maintained with a stable haploid background, making it easier to study the effects of mutations. In 1996, S288c became the first eukaryotic organism to have its genome completely sequenced, and strain libraries were subsequently developed for it, such as libraries of deletion and overexpression mutants, and strains with genes tagged by reporter genes. These libraries allow researchers to investigate the functional biology of every *S. cerevisiae* gene. The availability of such a powerful functional genomics toolkit has facilitated some remarkable discoveries, such as defining the yeast genetic and protein interaction networks. However, this reference strain provides very little information about the natural history of this species, and its combinations of alleles have never been exposed to selection in a natural setting. This strain is also an outlier in terms of its phenotypic properties, and the presence of auxotrophic markers (i.e., mutations that render a yeast cell unable to synthesize an essential compound) in its genome has serious consequences for many traits. In the past decade, we have witnessed a renewed interest in understanding the fascinating secret life of the budding yeast. On-going studies of thousands of isolates, both wild and those associated with human activities, will reveal the impact humans have had on the evolution of this species and will help to keep *S. cerevisiae* at the forefront of systems genetics.

Lifecycle outside of the lab

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The *S. cerevisiae* lifecycle, under precisely controlled laboratory conditions, is one of the best understood at the mechanistic level. Our ability to control its sexual cycle and to switch it between mitotic and meiotic reproduction is one of the great experimental strengths of this yeast system. Paradoxically, we know very little about its life cycle in natural settings, and what little we do know is indirectly inferred from

studying its life cycle in the lab, which precludes any firm conclusions. In the wild, yeast cells are found in fluctuating environments and are often subjected to a shortage of food. For instance, one of this yeast's natural habitats, oak bark, subjects it to seasonal cycles of tree sap flow, in addition to changing climate conditions. *S. cerevisiae* cells therefore likely spend much of their time in a non-dividing state called quiescence. When conditions become favourable, *S. cerevisiae* is able to grow on a modest array of fermentable and non-fermentable carbon sources (mostly six-carbon sugars). The availability of nutrients is likely to result in a rapid, mitotic clonal expansion of diploid yeast cells. Sexual cycles can be triggered by environmental cues, such as nutrient depletion, and result in the production of four meiotic spores that have two distinct mating types ( $a$  and  $\alpha$ ), analogous to human eggs and sperms. Meiotic spores tested in laboratory experiments are highly resistant to various stresses, such as high and low temperature and desiccation, and it is reasonable to assume that in a wild habitat they can persist for long periods of time until favourable, nutrient-rich conditions allow germination. Haploid spores eventually reestablish diploid lines, either by mating with their own mitotic daughter cells after switching mating type (haplo-selfing), by mating with another spore created by the same meiotic event (intratetrad mating) or, more rarely, by mating with an unrelated individual (outcrossing). These different mating solutions should have very different effects on species evolution and population structure. However, due to the microscopic size of yeast, the relative frequency of different modes of reproduction in the wild can only be inferred retrospectively by genome analysis. Population genomic studies indicate that budding yeast mostly reproduces asexually and that outcrossing is rare. Experiments have shown that outbreeding can be promoted by another popular model organism, the fruit fly *D. melanogaster*, which is attracted to and consumes yeast cells living on fruit in the wild and thereby acts as a vector, aiding their geographical dispersal. Furthermore, outcrossing is not restricted to mating within the species; introgressed genomic regions and interspecies hybrids with other closely related species are frequently observed. *S. cerevisiae* belong to a group of species named the *Saccharomyces sensu stricto* complex, which can generate viable hybrids when interbred. One fortunate example of this is the hybridization between *S. cerevisiae* and *S. eubayanus*, which led to the hybrid species *S. pastorianus*, used worldwide in the brewing industry to produce lager.

46. According to this article, how does the *S. cerevisiae* life cycle progress in the wild? (A) Wild yeast spend much of their time in mating status. (B) Wild yeast spend much of their time in mitosis status (C) Wild yeast spend much of their time in  $\alpha$ -type status (D) Wild yeast spend much of their time in non-dividing status.
47. What is the yeast strain used specifically for the production of lager beer? (A) *S. cerevisiae* (B) *S. eubayanus* (C) *S. sensu stricto* (D) *S. pastorianus*.
48. According to this article, who is the first person to try to create new brewing yeast by crossing yeast strains? (A) Carsberg (B) Ojvind Winge (C) Louis Pasteur (D) Emil Christian Hansen
49. What is the meaning of "auxotrophic" mutant? (A) A mutant is unable to synthesize a particular organic compound required for its growth (B) A mutant is can produce a particular organic compound required for its growth (C) A mutant requires double amount of a particular organic compound for its growth (D) A specific gene responsible for the production of a particular organic compound was deleted in yeast.
50. What is the first eukaryotic organism to have its genome completely sequenced? (A) *S. cerevisiae* (B) *D. melanogaster* (C) *S. eubayanus* (D) *E. coli*