# Critter Card:

### Chicken, *Gallus domesticus*

As a result of applied genetics, there are some sixty breeds of chickens around the world. Darwin himself described the features of Crest, Frizzle, Rose Comb, Lacing, and Creeper-varieties common in his time.

The most popular commercial egg-laying chickens today are Leghorns. They are hardy and prolific egg layers; a good hen lays 300 eggs per year!

Besides laying eggs, which they do whether they mate with a rooster or not, female chickens ("hens" if older than one year, "pullets" if younger than one year) do not crow (only roosters do this), and they have smaller wattles and combs than roosters. Wattles are the two fleshy red growths that hang from the side and base of a the beak; the comb is the fleshy red outgrowth on the head. These secondary sexual characteristics are well-developed in roosters.

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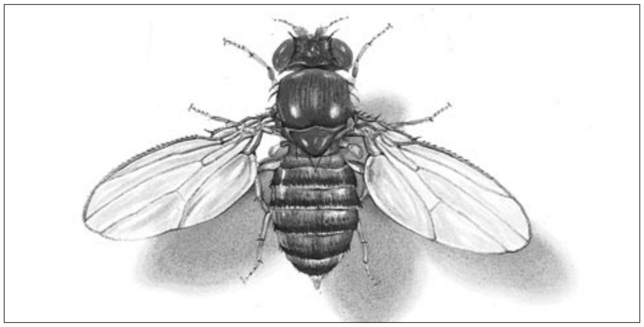
# Critter Card:

### Fruit Fly, *Drosophila melanogaster*



*D. melanogaster*, is one of the most common of the 900 species of fruit flies worldwide. The species epithet, *melanogaster*, derives from the distinctive dark pigmentation of distal regions of the male's abdomen. The female is about 11% larger than the male in linear dimensions. Their genitalia are strikingly different. In addition, on the male's foreleg, there are external sense organs called the "sex comb," which he uses in his courtship of the female.

Some might say that genetics owes more to the fortuitous selection of *D. melanogaster* as an experimental organism than to any other event that has occurred during its growth as a science. This small fly possesses every attribute a geneticist could wish to find—it thrives under laboratory conditions, it has a small genome (the sequence of the *D. melanogaster* genome was reported in March 2000), and it breeds rapidly. Total generation time (from egg to adult female fly to hundreds of her eggs) is only about two weeks!

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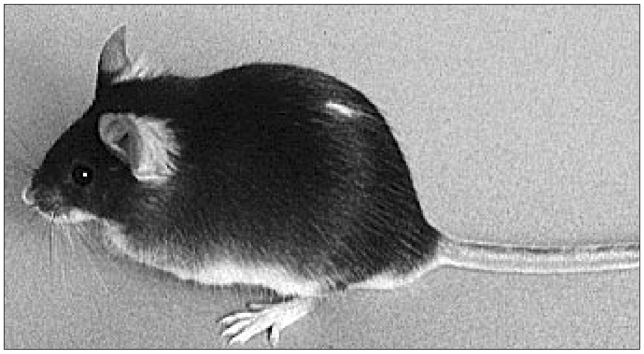
# Critter Card:

### House Mouse, *Mus musculus*



Since humans have been storing food, the house mouse has been tagging along with humankind. Because they were once collected and bred for their beauty (in 17th-century China and Japan), genetically identical strains of mice were created. This gave scientists purebred mouse lines dating back centuries. They are good model organisms for geneticists because of their short life spans (one to three years), small size, and ease of care. Mice are mammals like us, can live almost anywhere (human-made dwellings to fields and meadows), and eat almost anything (cereals, grass, seeds, roots, and even adult insects and larvae).

Mice reach puberty six to eight weeks after birth. Mature female mice, who are slightly smaller than males, have an estrous cycle ("go into heat") every four or five days! After a three-week gestation period, they give birth to five to ten pups (on average). The pups nurse for about four weeks.

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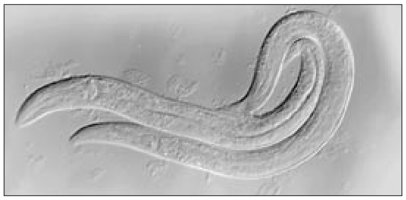
# Critter Card:

### Nematode, *Caenorhabditis elegans*



*C. elegans* is a tiny (1-mm-long) soil roundworm, or nematode. The genome sequence of *C. elegans*, the first complete sequence of a multicellular organism, was reported in December 1998. One biologist has remarked that *C. elegans* makes a good model organism because it's "a really stripped-down animal," with a small number of cells (about 1,000)—the developmental fate of each of which is known—and a transparent body, making its cells easy to observe under the microscope. Yet, *C. elegans* is a bona fide animal. It reacts to touch. It can recognize smells. It has muscles, nerves, guts, and sexual organs.

There are two sexual phenotypes in *C. elegans*: males, which have only testes, and hermaphrodites, which contain both testes and ovaries. Many aspects of anatomy and behavior are dramatically different between male and hermaphrodite worms. A male is both shorter (by 30%) and thinner than the hermaphrodite and is highly specialized for mating. This specialization is especially evident in the tail, which is equipped with various sensory and copulatory structures that enable him to locate the hermaphrodite's vulva and inseminate her.

A new generation of *C. elegans* can potentially be produced every three days!

# Critter Card:

### Spoon Worm, *Bonellia viridis*

The spoon worm's name comes from the scooplike proboscis overhanging its mouth. More than 150 species of these bizarre marine worms are found in environments extending from intertidal mudflats to sandy bottoms to depths of up to 10,000 m. In *B. viridis*, females (like the one pictured) are up to 2 m in length, including the highly extensible proboscis, while the males are merely 1-2 mm long and live as symbionts within the uterus of the female. This is perhaps the most extreme size difference between male and female (called "sexual dimorphism") found in the animal kingdom! Males release sperm that fertilize the female's eggs as they are being shed into the water. The fertilized eggs, at first enclosed in a gelatinous string, develop into free-swimming, sexually undifferentiated larvae.

# Critter Card:

### Yellow-Spotted Amazon River Turtle, *Podocnemis unifilis*

The yellow-spotted Amazon River turtle gets its name from the bright yellow spots found on its gray-olive head. Males (like the one shown above) are smaller than females, although males have longer and thicker tails. A freshwater turtle, *P. unifilis* prefers lakes, ponds, swamps, lagoons, and oxbows along major Central and South American rivers, including the upper tributaries of the Amazon River in Colombia, eastern Ecuador, northeastern Peru, northern Bolivia, southern Venezuela, and Brazil. The International Union for the Conservation of Nature and Natural Resources (IUCN) names it as a Vulnerable Species on its 2000 Red List of Threatened Species. In the Conservation Program for Amazonian Freshwater Turtles, *P. unifilis* eggs are transported from unprotected nesting areas to protected ones to aid the species' survival.

# Critter Card:

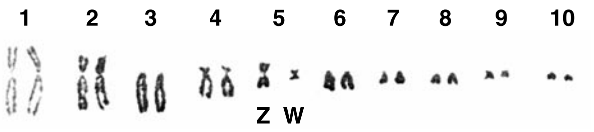
### White Campion, *Silene latifolia*

White campion, or white cockle, is an herbaceous plant found throughout most of the United States. Unlike many flowering plants, white campion consists of "male" and "female" individuals. Males (shown above) bear staminate flowers, having only stamens (the flower organs in which pollen develops). Females bear carpellate flowers, containing only carpels (the organs in which ovules develop). Very young blossoms of males and females are indistinguishable. White campion is a dioecious species, which have staminate and carpellate flowers on separate plants.

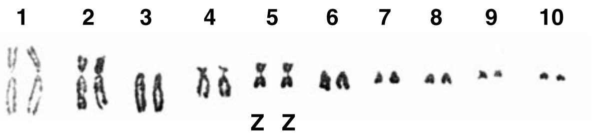
# Karyotype Card

It was not until the development of improved preparative techniques in the 1960s that accurate counts of avian chromosomes became generally available. The earlier problems stemmed from the fact that birds have two classes of chromosomes: macrochromosomes (which are large and easy to count) and microchromosomes (which are tiny, frequently lost during the making of chromosome spreads, and practically impossible to distinguish from one another). Chickens have 10 pairs of macrochromosomes and 29 pairs of microchromosomes. Only the macrochromosomes are shown below, because male and female chickens' karyotypes do not differ in their microchromosomes.

**Hen macrochromosome karyotype**



**Rooster macrochrosome karyotype**



**CHICKEN**

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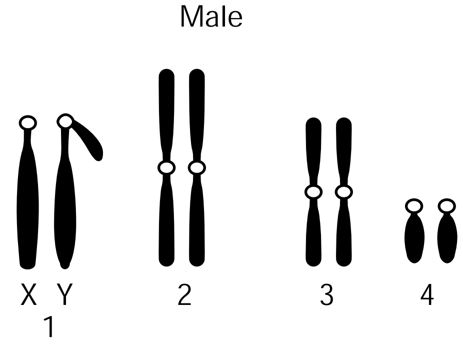
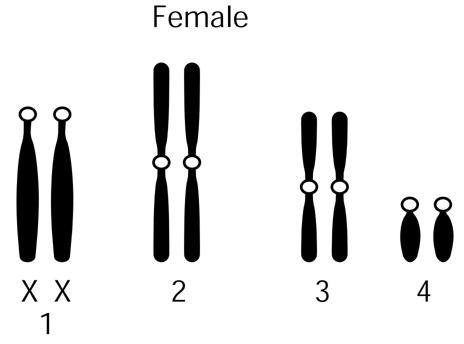
# Karyotype Card

***D. melanogaster*** **karyotypes**





**FRUIT FLY**

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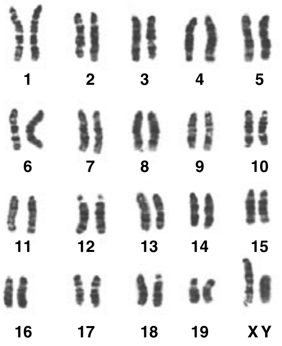
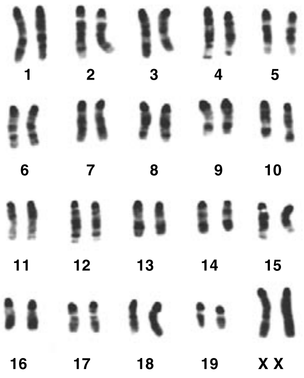
# Karyotype Card

**Male mouse karyotype**



**Female mouse karyotype**



**MOUSE**

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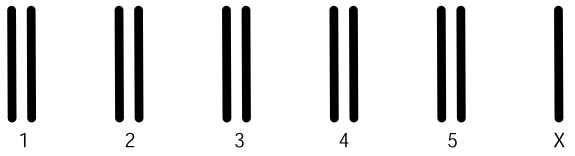
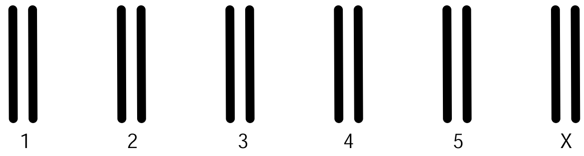
# Karyotype Card

**Male *C. elegans* karyotype**



**Hermaphrodite *C. elegans* karyotype**



**NEMATODE**

## Karyotype Card

No karyotype has ever been made. Can you predict what the male and female karyotypes might look like?

**SPOON WORM**

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## Karyotype Card

**Figure 1. Male yellow-spotted river turtle karyotype.**

**Figure 2. Female yellow-spotted river turtle karyotype.**

*Note: Some variations in appearances may be due to artifacts of preparation*

**TURTLE**

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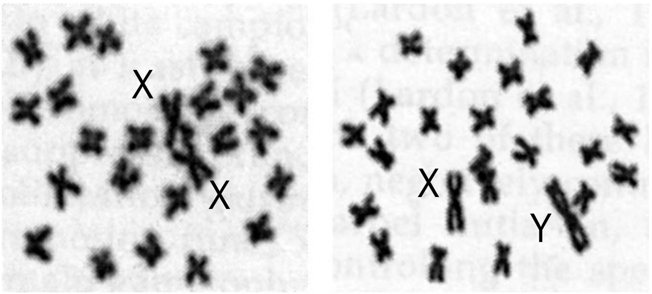
## Karyotype Card

**White campion female (left) and male (right).**
**"X" and "Y" label the sex chromosomes.**



**WHITE CAMPION**

# Observation Card #1

Human males inherit a Y chromosome from their fathers; human females have two X chromosomes. The W chromosome of birds superficially resembles the Y chromosome of humans in several ways. Like the human Y, the avian W is largely heterochromatic, late replicating, and pairs with just a small region of the other sex chromosome (the Z, in birds) during meiosis. However, the sex chromosomes of birds and mammals are thought not to be homologous, having evolved from different autosomal pairs. Figure 1 shows a female chicken, and Figure 2 shows a human male.

**Figure 1. Chicken female.**

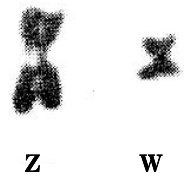
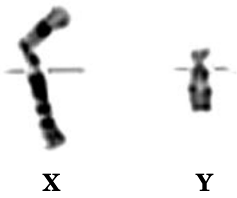


**Figure 2. Human male.**



**CHICKEN**

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# Observation Card #2

As a result of selection by poultry geneticists or “accidents” of meiosis, chickens with unusual numbers of chromosomes have been produced. For example, M.H. Thorne (1991), starting with a crossbred flock originating from White Leghorn x Australorp varieties, artificially selected for a line of triploid chickens by using inbred matings. Triploidy refers to having three sets of each chromosome, instead of the normal two.

Data on the relationship between karyotype and sex determination in chickens are summarized in Table 1. “A” refers to a set of autosomes; thus, “2A” denotes a diploid bird, and “3A” denotes a triploid bird.

**Table 1. Relationship between karyotype and sex determination in chickens.**

| Karyotype | Sex | Z:A ratio* |
|---|---|---|
| 2A, ZZ | Male | 1:1 |
| 2A, ZW | Female | 1:2 |
| 2A, ZZW | There is one report of a chicken like this in the literature. In 1933, F.A.E. Crew described a ZZW chicken—a male. | 1:1 |
| 3A, ZZZ | Male (but infertile) | 1:1 |
| 3A, ZZW | Intersex | 2:3 |
| 3A, ZWW | There is one report of a chicken embryo like this in the literature. It died on day 16 of incubation, and it reportedly had ovaries. | 1:3 |

**Hint: To see a pattern, try expressing the Z:A ratio as a decimal.*

**CHICKEN**

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# Observation Card # 3

Unusual birds called bilateral gynandromorphs may shed some light on avian sex determination. A bilateral gynandromorph is a genetic chimera, with the right and left sides of its body expressing different genes. Loss or nondisjunction of a sex chromosome at first cleavage may explain some gynandromorphs. F.B. Hutt (1949), writing on the expression of a particular Z-linked codominant trait, concluded that one chicken gynandromorph was ZZ (male side)/ZO (female side). F.A.E. Crew and S.S. Munroe (1938) concluded that gynandromorphs in several finch species were also of the ZZ (male)/ZO (female) constitution.

**CHICKEN**

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# Observation Card #1

An early mutation recovered in T.H. Morgan’s Columbia University fly lab was the recessive sex-linked white-eye character. When wild-type red-eyed males were crossed with mutant white-eyed females, the offspring were typically red-eyed daughters and white-eyed sons. (Convince yourself of this!) But there were exceptions: There were a few white-eyed *daughters* and red-eyed *sons!*

C. Bridges (1916) proposed that these exceptional flies had resulted from a type of meiosis abnormality called nondisjunction. Instead of making eggs with one X chromosome (and one of each autosome), the female fruit fly’s two X chromosomes had, on occasion, failed to separate, producing eggs that had an extra X or no X. If XX or O eggs (“O” is a placeholder; it stands for the missing X) were fertilized by X- or Y-bearing sperm, four types of progeny would be expected (see Table 1). Bridges’ hypothesis was later confirmed by microscopic examination of *Drosophila* chromosomes.

**Table 1. Four types of progeny.**

| Gametes from nondisjunction in the white-eyed female | Gametes from the red-eyed male | Exceptional offspring sex-chromosome combinations | Exceptional offspring phenotypes |
|---|---|---|---|
| XX | X | XXX | Female, red-eyed |
| XX | Y | XXY | Female, white-eyed |
| O | X | XO | Male, red-eyed |
| O | Y | OY | Dies before hatching |

**FRUIT FLY**

# Observation Card # 2

From 1921 to 1925, C. Bridges studied triploid fruit flies-females that had three copies of each chromosome (including 3 Xs) in every cell instead of two. These rare triploid females apparently originate when normal haploid sperm fertilize diploid eggs. Triploid females are heavyset, with coarse bristles and eyes. Because of their unusual chromosome constitution, triploid female flies produce a variety of eggs in meiosis. Bridges crossed triploid females and normal males and observed that a melange of fruit fly offspring resulted (see Table 1). "A" refers to a set of autosomes; "2A" is thus a normal diploid fly.

**Table 1. Offspring of triploid females and normal males.**

| Offspring chromosomes | X:A ratio in offspring* | Sex of the offspring fly |
|---|---|---|
| XXX, 2A | 3:2 | Female, but weak and infertile |
| XXX, 3A | 1:1 | Female |
| XX, 2A | 1:1 | Female |
| XXX, 4A | 3:4 | Intersex; expresses both male and female traits; also sterile |
| XX, 3A | 2:3 | Intersex; expresses both male and female traits; also sterile |
| XO, 2A | 1:2 | Male (Note: "O" is a placeholder; "XO" means one X was inherited.) |
| XY, 2A | 1:2 | Male |
| XY, 3A | 1:3 | Male, but weak and infertile |

**Hint: To see a pattern, try expressing the X:A ratio as a decimal.*

**FRUIT FLY**

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# Observation Card #3

The unique fruit fly shown in Figure 1 appeared in a stock culture in which all other females were heterozygous for the X-linked recessive characters white eye (w) and miniature wing (m). This kind of fly is known as a bilateral gynandromorph. The left side of its body exhibits a male phenotype (also white eye and miniature wing), and the right side exhibits a female phenotype (also red eye and normal wing).

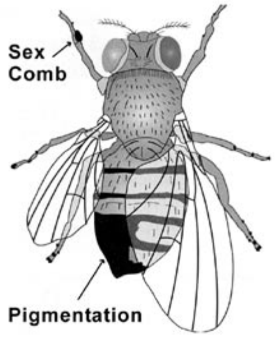

**Figure 1. The loss of one X chromosome in one of the two cells during the first mitotic division resulted in a bilateral gynandromorph of *Drosophila melanogaster*.**

How can both sexes be present in one animal? Biologists surmise that this gynandromorph began life as an XX female. However, as a result of the first mitotic division, one of its two X chromosomes was lost in one of the cells. Judging by the fly's appearance, the cell on its left is the one that became XO (the "O" is a placeholder; it stands for the missing sex chromosome). The "line" demarcating male vs. female development depends on the orientation of the spindle during the first mitotic division.

**FRUIT FLY**

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# Observation Card #1

*B. viridis* larvae, which do not look like either males or females at first, are free swimming. If a larva settles on the proboscis of an adult female, the larva attaches itself to the proboscis, and, after several days, it undergoes a gradual metamorphosis to a male. The male then is carried by the female's proboscis to the trunk, where it enters the uterus of the female and lives as a symbiont the rest of its life. If, however, chance leaves the free-swimming larva far removed from an adult female, it becomes a female.

M. Gould-Somero (1975) describes the adaptive significance of *B. viridis* sex determination this way: "Adult females inhabit holes and cracks in rocks, and once settled, are presumed to remain stationary, extending their enormous ciliated proboscises to gather food and husbands. Thus, undifferentiated larvae that settle in areas already heavily colonized will tend to encounter a proboscis and become males. Pioneer settlers will tend to become females."

**SPOON WORM**

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# Observation Card # 2

In 1931 and 1932, F. Baltzer removed *B. viridis* larvae, having begun to differentiate as males, from the proboscises of adult females and placed them in seawater. The larvae developed as intersexes, having features of both males and females. The degree of intersexuality was approximately correlated with the duration of the initial attachment period. The shorter the attachment period, the more female the intersex worms appeared; the longer the attachment period, the more male the intersex worms appeared.

**SPOON WORM**

# Observation Card # 3

In the lab, F. Baltzer (1932) raised 390 B. viridis larvae together in a big bowl of pure seawater and 409 larvae together in a big bowl of water containing chopped-up pieces of female proboscises. He then waited to see what sex the larvae would grow up to be. His data are shown in Table 1.

**Table 1. Sex of *B. Viridis* larvae.**

| Lab Environment | Female (%) | Male (%) | Intersex (%) | Dead (%) |
|---|---|---|---|---|
| Pure seawater | 86.6 | 1.4 | 6.3 | 5.6 |
| With pieces of female proboscis | 20.2 | 70.7 | 0.5 | 8.5 |

**SPOON WORM**

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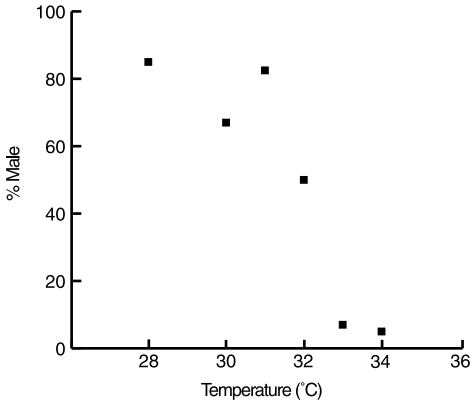
# Observation Card #1

R. Souza and R.C. Vogt (1994) conducted egg incubation temperature studies on one-week old eggs of *P. unifilis* in the laboratory. The eggs, collected from several different natural nests along the Guapore River, were reburied in artificial nests of similar texture and depth and incubated under constant-temperature laboratory regimes. Thirty eggs were incubated at each temperature. Data on hatchling sex ratio for each incubation temperature are shown in Figure 1.

**Figure 1. Sex ratio (100 % = all males) of embryos incubated at constant temperatures of 28°C, 30°C, 31°C, 32°C, 33°C, and 34°C.**



**TURTLE**

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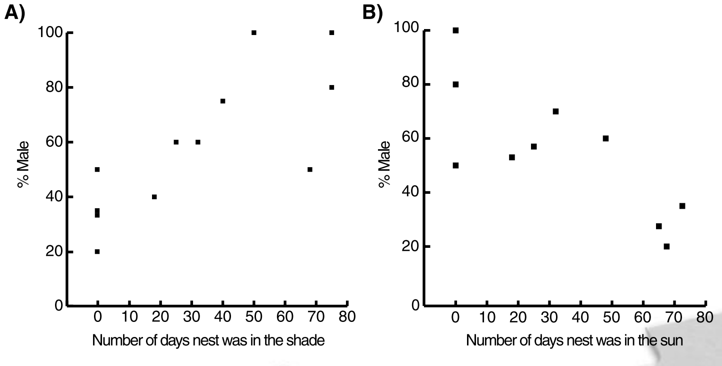
# Observation Card #2

R. Souza and R.C. Vogt (1994) conducted hatchling sex ratio studies on natural *P. unifilis* nests found along the Guapore River. Twenty nests of similar age, substrate, and clutch size were used in their study; ten were shaded with palm fronds, and ten were left undisturbed. At intervals during incubation, Souza and Vogt switched four eggs from each of six nests in the shade to six nests in the sun. They also did the complementary experiment, switching four eggs from each of six nests in the sun to six nests in the shade. Sex ratio data for the shade-to-sun and sun-to-shade experiments are summarized in Figures 1A and 1B, respectively.

**Figure 1. A) Sex ratio (100% = all males) as a function of the number of days the nests were exposed to shaded conditions. B) Sex ratio (100% = all males) as a function of the number of days the nests were exposed to the sun.**



**TURTLE**

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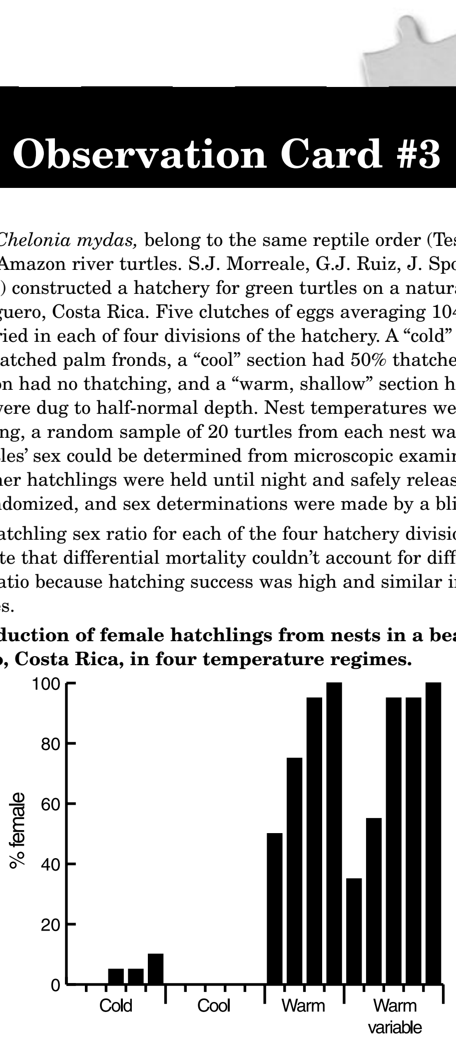
# Observation Card #3

Green turtles, *Chelonia mydas,* belong to the same reptile order (Testudines) as yellow-spotted Amazon river turtles. S.J. Morreale, G.J. Ruiz, J. Spotila, and E. Standora (1982) constructed a hatchery for green turtles on a natural nesting beach at Tortuguero, Costa Rica. Five clutches of eggs averaging 104 eggs per clutch were buried in each of four divisions of the hatchery. A "cold" section was created with thatched palm fronds, a "cool" section had 50% thatched palm fronds, a "warm" section had no thatching, and a "warm, shallow" section had no thatching and nests were dug to half-normal depth. Nest temperatures were monitored daily. At hatching, a random sample of 20 turtles from each nest was euthanized so that the turtles' sex could be determined from microscopic examination of the gonads. (All other hatchlings were held until night and safely released to the sea.) Slides were randomized, and sex determinations were made by a blind protocol.

Data on hatchling sex ratio for each of the four hatchery divisions are shown in Figure 1. Note that differential mortality couldn't account for differences in hatchling sex ratio because hatching success was high and similar in all four thermal regimes.

**Figure 1. Production of female hatchlings from nests in a beach hatchery at Tortuguero, Costa Rica, in four temperature regimes.**



**TURTLE**

# Observation Card #1

*Scurfy* (sf) is a sex-linked, recessive mouse characteristic in which affected mice have tight, scaly skin, are small, and die at an early age. W.L. Russell, L.B. Russell, and J.S. Gower (1959) crossed wild-type females who carried *scurfy* with wild-type males. Although the scientists expected that only male offspring would be *scurfy*, a few *scurfy* females resulted. Later, biologists counted the chromosomes of these "exceptional females" and found 39 instead of 40. Because they would have died before having babies of their own, the ovaries of the unusual *scurfy* females were transplanted into host female mice whose ovaries had been removed. Then, the host mice were mated with wild-type males. Based on the baby mice that resulted-for example, exceptional females' sons were always *scurfy*-Russell and colleagues proposed an unusual origin for the exceptional *scurfy* females. See Table 1 (+ is the wild-type allele of *scurfy*).

**Table 1**

| | **Sex chromosomes in gametes of female mouse parent** | |
|---|---|---|
| Gametes after nondisjunction (faulty meiosis) of sex chromosomes in male mouse parent | $X^+$ | $X^{sf}$ |
| O ("O" is a placeholder for the missing chromosome) | $X^+$ O | $X^{sf}$ O |
| $X^+$ Y | $X^+$ $X^+$ Y | $X^+$ $X^+$ Y |

*Russell et al. (1959) had found that mice with an XO genotype are female!*

**MOUSE**

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# Observation Card # 2

In the early 1960s, in B. Cattanach's mouse genetics lab, a female mouse homozygous recessive for pink and chinchilla (two color traits encoded by genes on chromosome 7) was mated to a wild-type male. Sounds pretty straightforward, but the male had an unusual genotype: One set of wild-type alleles for pink and chinchilla was on chromosome 7 as expected, but the other pair of wild-type alleles was attached to his X chromosome! In other words, a translocation event had occurred between the male's X and one of his 7s, resulting in an X with a little bit of 7 on it, and a 7 with a little bit of DNA deleted.

"Flecked females" are expected from such a cross. They are daughter mice who inherit pink and chinchilla alleles on their mother's 7, no color alleles on their father's deletion 7, and wild-type color alleles on their father's translocation X. They are, in effect, heterozygotes. Every cell of an XX female mammal randomly inactivates one of its two Xs. Thus, owing to the 50% of their skin cells in which the translocation X was shut off, these daughter mice are "flecked," or highlighted, with pinkish-cream streaks on top of their normal fur color.

The real surprise came when, among hundreds of offspring of crosses like the ones just described, Cattanach found a few flecked males! Though sterile, the unusual males had testes and exhibited normal mating behavior. Counts revealed that the unusual flecked males had 41, not 40, chromosomes. Cattanach proposed that as a result of a faulty meiosis in their father, the unusual flecked mice were XXY. Yet, even with two Xs, they were male!

**MOUSE**

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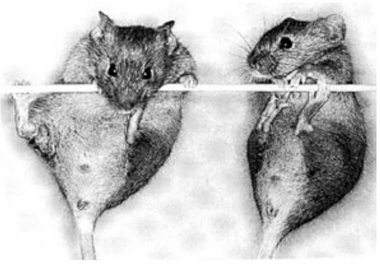
# Observation Card #3

In 1991, a team of British researchers led by P. Koopman collected fertilized eggs from mated female mice. Then, they injected the zygotes with tiny fragments of mouse Y chromosome DNA. The fragment of mouse Y was chosen because it was homologous to a region of the human Y thought to be involved in sex determination. The injected zygotes were then cultured to the two-cell stage and implanted into the oviducts of female mice prepared with hormones to induce pregnancy.

Ninety-three mice were born; five were transgenic. One of the transgenics, m33.13, was chromosomally female—that is, XX—yet was phenotypically male! He was similar in size and weight to his normal XY male littermates. When caged with females, his copulatory behavior was normal. The only difference between m33.13 and his male siblings was in the size of the testes; those of m33.13 were much smaller (see Figure 1). Histological examination of testis sections from m33.13 showed seminiferous tubules and apparently normal populations of Leydig and Sertoli cells, but no cells undergoing spermatogenesis. Not surprisingly, m33.13 was sterile.

**Figure 1. External genitalia of 33.17 (left) and 33.13 (right).**



**MOUSE**

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# Observation Card #1

Hermaphrodites are anatomically females, but they also produce a limited number of sperm with which they fertilize their first batch of eggs internally.

Once hermaphrodites are inseminated by males, the males' sperm are used "preferentially." The hermaphrodite is not consciously deciding to do this; rather, the sperm of a male are bigger than her own and able to outcompete hers for access to eggs.

**NEMATODE**

# Observation Card #2

Figure 1 compares the outcomes of self-fertilization in a hermaphrodite with those in a mating of hermaphrodite and male. When a hermaphrodite self-fertilizes (resulting in her first batch of progeny), 99% of the progeny are hermaphrodites and less than 1% are males. After the hermaphrodite runs out of her own sperm, she is functionally female and must mate with a male to fertilize her remaining oocytes. Progeny are about half males and half hermaphrodites.

How are *any* males produced from hermaphrodite (XX) self-fertilization? It turns out that males made this way result from a spontaneous meiosis "error" in the hermaphrodite. Less than 1% of the time, the X is "lost" in meiosis. Gametes like this are designated "O" and are called "nullo-X gametes." (The "O" acts as a placeholder for the missing X.) At fertilization, nullo-X and X gametes fuse to make XO males.

When XO males have meiosis, 50% of the gametes are X sperm and 50% are nullo-X sperm. Thus, when a male and a hermaphrodite mate, they have 50% males and 50% hermaphrodites. (Prove this to yourself with a Punnett square!)

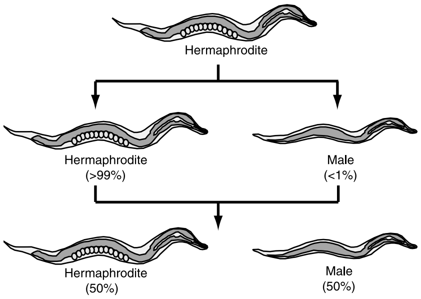

**Figure 1. The outcomes of self-fertilization in an hermaphrodite and a mating of a hermaphrodite and a male worm.**

**NEMATODE**

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# Observation Card #3

J.E. Madl and R.K. Herman (1979) produced *tetraploid* stocks of *C. elegans* by culturing the nematodes at higher than normal temperatures and repeatedly selecting for larger and more fertile worms. Microscopic analysis confirmed the creation of *C.* elegans hermaphrodites with *four* of each chromosome, including four Xs, instead of the normal two. When these animals mated with normal males, a variety of offspring resulted (probably because meiosis in the tetraploid worm gave rise to a variety of eggs, some of which had unusual numbers of chromosomes). The sex of the resulting offspring is shown in Table 1. "A" represents a set of autosomes; thus, "2A" denotes a normal diploid worm.

**Table 1. Sex of resulting offspring**

| Chromosomes of offspring | Ratio of X chromosomes to autosomes in offspring* | Sex of offspring |
|---|---|---|
| 1 X, 2A (normal) | 1:2 | Male |
| 2 X, 4A | 1:2 | Male |
| 2 X, 3A | 2:3 | Male |
| 3 X, 4A | 3:4 | Hermaphrodite |
| 2 X, 2A (normal) | 1:1 | Hermaphrodite |
| 3 X, 3A | 1:1 | Hermaphrodite |
| 4 X, 4A | 1:1 | Hermaphrodite |

**Hint: To uncover a pattern, try converting X:A ratios to decimals.*

**NEMATODE**

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# Observation Card #3

When G. van Nigtevecht (1966) crossed two white campions (a carpellate and a staminate individual), 98 offspring plants resulted: 52 with female (carpellate) blossoms, 45 with male (staminate) blossoms, and one with hermaphrodite blossoms (flowers with both stamens and carpels). Upon further examination, van Nigtevecht learned that the hermaphrodite had inherited a Y chromosome with a deletion. All of the karyotypically male offspring of the hermaphrodite received the abnormal (deletion-bearing) Y chromosome and were hermaphrodites, too.

According to M. Westergaard (1946), when a part of one arm of the Y chromosome is missing, carpels sometimes develop next to the stamens in the XY plant's flowers. When part of the other arm of the Y chromosome is missing, the development of the stamens is arrested immediately after meiosis.

**WHITE CAMPION**

# Observation Card #1

H.E. Warmke (1946) soaked white campion seeds with a solution of colchicine, known to disrupt mitosis and induce polyploidy (having more than two complete chromosome sets) in plants. He then crossed the polyploid plants in various combinations. Since meiosis is not normal in polyploids, Warmke was able to generate offspring with novel numbers of sex chromosomes (see Figure 1). Table 1 shows the relationship between white campion sex and chromosome constitution (determined through microscopic analysis of root tip squashes). “A” refers to a complete set of autosomes; thus, “2A” is a normal diploid plant.

**Figure 1. Flowers and drawings of somatic chromosomes from 4A XXXY and 4A XXX plants.**

4A XXXY - MALE
(occasional hermaphrodite blossom)

4A XXX - FEMALE

**Table 1. Relationship between white campion sex and chromosome constitution.**

| Chromosomes | Sex |
|---|---|
| 2A, XX | Female (normal) |
| 2A, XXY | Male with less than 1% hermaphrodite blossoms |
| 4A, XX | Female |
| 4A, XXY | Male with occasional hermaphrodite blossom |
| 4A, XXYY | Male |
| 4A, XXX | Female |
| 4A, XXXY | Males almost exclusively |
| 4A, XXXX | Female. |
| 4A, XXXXY | Hermaphrodite blossoms and occasional taminate blossoms but no carpellate blossoms |

# Observation Card #2

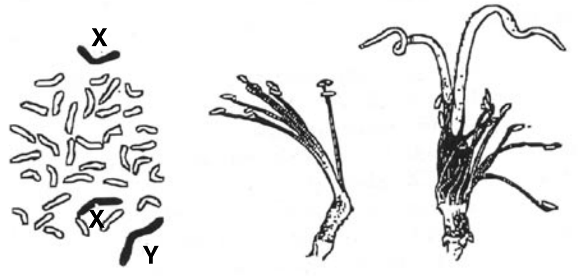
The experiments by H.E. Warmke (1946) with polyploid white campion plants yielded the data shown in Table 1. “A” refers to a complete set of autosomes; thus, “2A” is a normal, diploid plant.

**Table 1.**

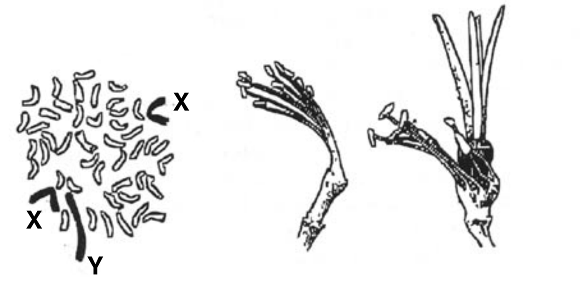
| Chromosomes | Sex |
|---|---|
| 2A, XXY | large majority of staminate blossoms, with an occasional hermaphrodite blossom |
| 3A, XXY | large majority of staminate blossoms, with an occasional hermaphrodite blossom |
| 4A, XXY | large majority of staminate blossoms, with an occasional hermaphrodite blossom |

**Figure 1.**

**2A XXY - MALE**
(occasional hermaphrodite blossom)



**3A XXY - MALE**
(occasional hermaphrodite blossom)



**4A XXY - MALE**
(occasional hermaphrodite blossom)