

# Sociobiology

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# Sociobiology

“the systematic study of the biological basis of social behavior”

Edward O. Wilson

# The Nobel Prize in Physiology or Medicine 1973



Photo from the Nobel Foundation archive.

**Karl von Frisch**

Prize share: 1/3

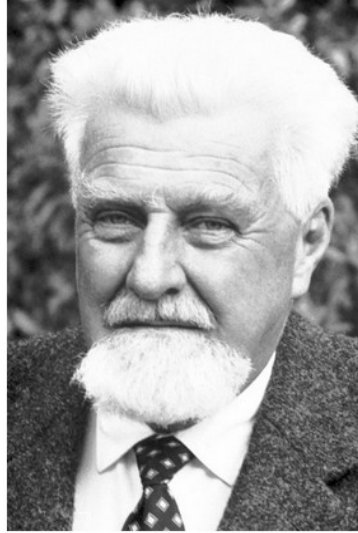


Photo from the Nobel Foundation archive.

**Konrad Lorenz**

Prize share: 1/3

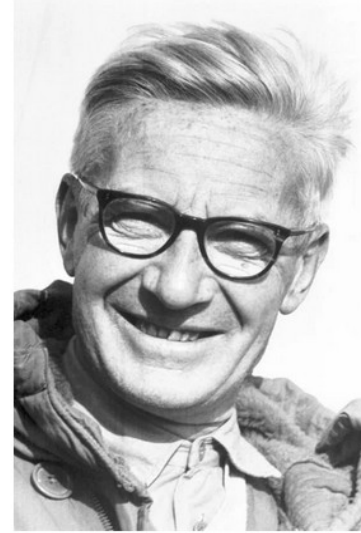


Photo from the Nobel Foundation archive.

**Nikolaas Tinbergen**

Prize share: 1/3

The Nobel Prize in Physiology or Medicine 1973 was awarded jointly to Karl von Frisch, Konrad Lorenz and Nikolaas Tinbergen "for their discoveries concerning organization and elicitation of individual and social behaviour patterns"

i.e., "animal behavior" or "ethology"

## von Frisch:

Investigated how bees communicate information; apparently genetically programmed and not learned.

Returning bee performs round dance when returning after finding honey source; other bees participate in dance by circling with her, then go outside hive to search for source by circling hive.

If source is more than 50 m from hive, she performs “waggle dance”; she moves forward, while dancing, for short distance, turns to one side, runs back to starting position, repeats dance, turns in opposite direction, runs back to starting position, etc.; movement is upward at angle from vertical to show direction to source from sun’s position which is designated as straight up in hive; if sun not visible, analysis is made of polarized, UV light; dancing intensity indicates closeness of source (more intense = closer).

## Lorenz:

Studied “instinctive” activities (irreversible behavior patterns) in birds elicited by specific “key stimuli”; these activities occurred in “naïve” birds (born in incubators), so were not learned.

For example, newborn ducklings will follow first moving object they see such as mother, cardboard box, or balloon. Such behavior is termed “imprinting”.

## Tinbergen:

Analyzed elements and strength of key stimuli which elicit particular responses; a probing of “instincts”.

For example, exaggeration of the form, colors, and contrasts of dummy newborn seagull bills elicit more intense parental feeding behavior.

The latter awardees also studied the overlap of apparently genetically based influences on more nuanced behavior such as courtship and reproduction. For example, Tinbergen elucidated the inherent courting, mating, and young rearing behavior of stickleback fish.

# Review of Human Genetics

$3 \times 10^9$  base pairs in human nuclear reference genome

with variation of  $\sim 1/1000$  base pairs

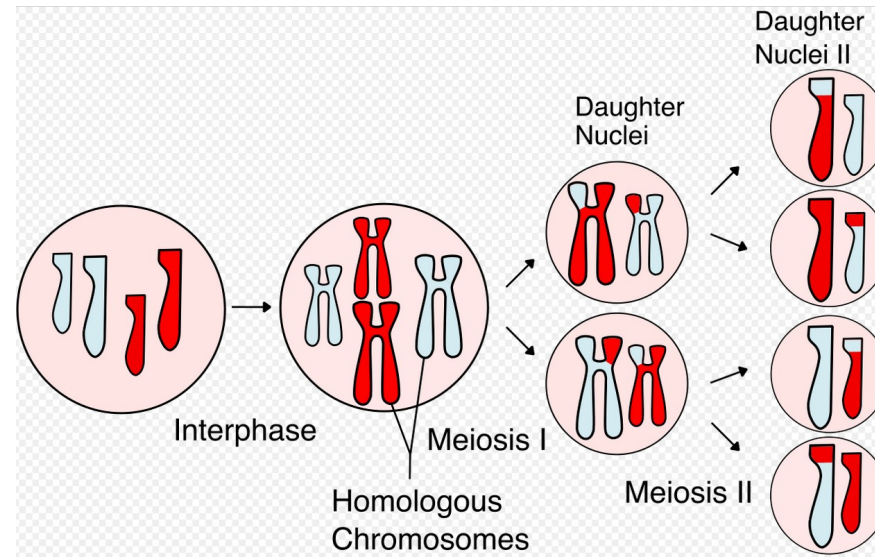
$2 \times 10^4$  genes in human genome

gene size varies:  $5 \times 10^2$  to  $2.3 \times 10^6$  base pairs

with average of  $3 \times 10^3$  base pairs

Therefore: 1% of DNA is coding, 99% is non-coding

# Meiosis

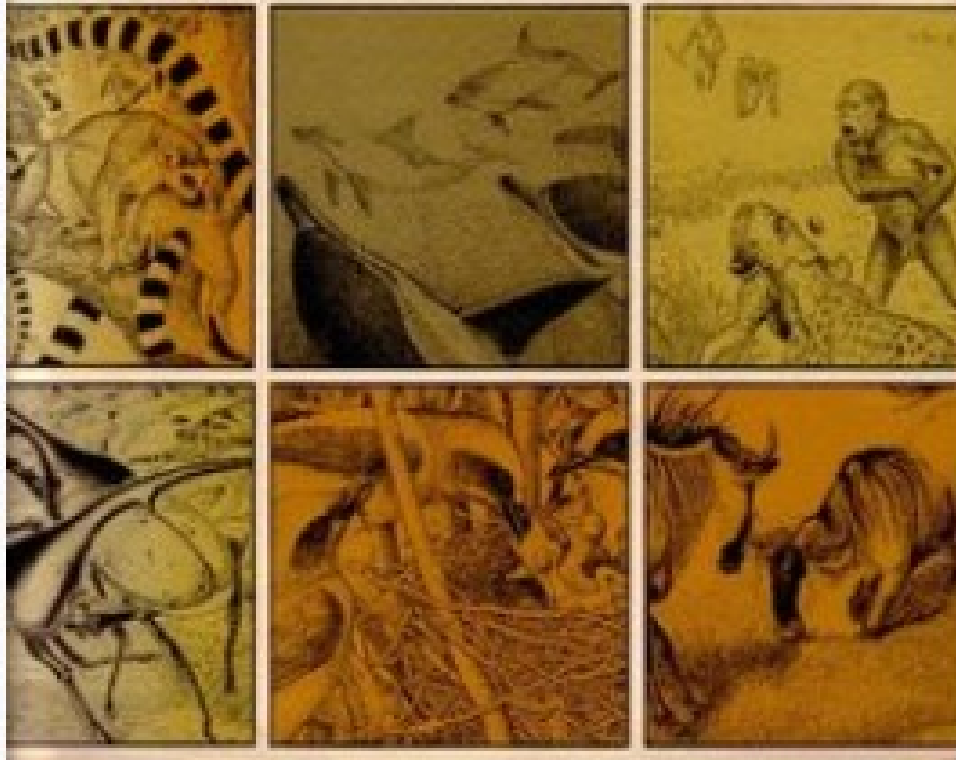


Meiotic Recombination: On average, there are 33 recombinations per chromosome per meiotic event!

# Sociobiology

THE NEW SYNTHESIS

Edward O. Wilson



Wilson in 2007

# Sociobiology Concepts

Wilson also defined Sociobiology as “the extension of population biology and evolutionary theory to social organization”.

- A. All individuals in animal societies possess two traits: self-preservation and altruism. These traits (instincts) override consciousness and drive individual actions.
- B. Behavior is the product of natural selection of genes. For example, DNA of individual→mating→care of offspring→altruism. More and more complex interactions of genetic products often cause altruism to override self-preservation (which maintains individual’s genes) to perpetuate species via populations.
- C. For humans, emotions are controlled by the hypothalamus and the limbic system. This means genes which underlie brain formation underlies conscious and unconscious behavior.
- D. Example: Societal comparison of termites and monkeys.
  - 1. Communication of hunger, alarm, hostility, caste status or rank.
  - 2. Reproductive status via 10-100 nonsyntactile signals.
  - 3. Awareness by individuals of distinction between groupmates and nonmembers.
  - 4. Kinship is important. Labor is divided. Fruits of cooperation depend on particular conditions of environment.
- E. Wilson thought of Sociobiology more from a social evolutionary description rather than from a molecular biology perspective. A difficulty for acceptance of Sociobiology is the presence of hierarchies where dominance doesn’t occur but higher levels control lower levels. In these instances, there are often few social bonds and loose communication abilities. For humans, there are many social bonds and rich language communications.



F. Societal qualities for organized study of social changes and adaptations.

1. Group size; e.g., primate troops.
2. Demographic Distribution; frequencies of individuals with specific traits or roles.
3. Cohesiveness; honeybees are quite cohesive, chimp troops are less cohesive.
4. Amount and Pattern of Connectedness; types of communication networks.
5. Permeability; ease of movements of individuals between groups (acceptance or intolerance).
6. Compartmentalization; e.g., subgroup organization when responding to danger.
7. Differentiation of Roles; social evolution advances with specialization of group members.
8. Integration of Behavior; group of generalists vs. set of specialists with correct individual proportions and with coordinated behaviors.
9. Information Flow; communication magnitude.
10. Fraction of Time Devoted to Social Behavior; degree of sociality is directly proportional to time spent on individual social behavior.

G. Evolutionary theory applied to sociobiology.

1. Adaptive vs. Nonadaptive Traits; adaptive maintains population by selection, nonadaptive otherwise.
2. Nonadaptive vs. Polyadaptive Traits; aggression is polyadaptive.
3. Reinforcing vs. Counteracting Selection; natural selection force on a gene may multiply from individual to family to troop to population.
4. Ultimate vs. Proximate Causation; e.g., senescence where natural selection, which takes generations to manifest, is balanced against individual's anatomy, physiology, and behavior.
5. Ideal vs. Optimum Permissible Traits; e.g., horn size on mountain sheep (keep harem vs. mechanical stress and maneuverability control).
6. Potential vs. Operational Factors; growth and persistence of populations depends on genetic based ability.
7. Deep vs. Shallow Convergence; e.g., deep – role of eye for mollusks' and vertebrates' behavior, shallow – territoriality and dominance for many species.
8. Grades vs. Clades; grades – species going through a “vertical” evolutionary path, clades – species split forming new species having same traits as each other.
9. Instinct vs. Learned Behavior; instinct has a genetic component, e.g., male silkworm moth attraction to female sex hormone, learned behavior – varied response by primates to speech patterns.

## H. Heredity.

$$(a + b)^2 = a^2 + 2ab + b^2 \text{ where } a \text{ is gene 1 and } b \text{ is gene 2.}$$

1. Genetic Drift occurs when small groups of a population are selected by environmental influences; eventually they can dominate the population (i.e., evolution).
2. Gene Flow occurs when different individuals immigrate into a population.
3. Selection is the change in relative frequency of a trait in generations due to phenotype's ability to have representation in next generation through environmental pressure; i.e., the fitness of a phenotype (with underlying genotype).
4. Evolution in Terms of Gene Frequency.

$$dp_x/dt = p_x(r_x - r_0) \text{ where } p_x = n_x/N$$

with  $n_x$  is the # of copies of gene  $x$  in population and  $N$  is total # of genes of all alleles

$$\text{and } r_x = (dn_x/dt)/n_x \quad r_0 = (dN/dt)/N$$

thus,  $p_x$  is the frequency of gene  $x$ ,  $r_x$  is the fitness of gene  $x$ , and  $r_0$  is the average rate of increase (change?) of all alleles.

## I. Heritability.

1. Phenotype variation depends on gene differences and environmental variations during individual lifetimes.
2. Individuals can have different heritability score in different environments even with same genes.
3. Speed of Evolution; equals heritability times intensity of selection process.
4. Cyclical selection can occur where the favorability of different genes depends on environmental changes at different times of organism's life with concomitant selective pressures.

## J. Human Evolution.

1. Humans have evolved to have erect posture, bipedal locomotion, enlarged thumb, lengthened leg, narrowed and lengthened foot, mostly lost hair, changed estrous cycle, and copulation is initiated by foreplay rather than pheromones or skin color changes.
2. Human brain volume has greatly increased, mental abilities (intelligence, drive, creativity, communication, social interactions, etc.) have tremendously expanded.
3. Humans barter and exhibit reciprocal altruism which leads to economics and law.
4. Humans have developed rituals, culture, religions, ethical values, etc.
5. Sexual selection, rather than polygyny, may have fostered human evolution.