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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE TRADEMARK TRIAL AND APPEAL BOARD

Proceeding	91205081
Party	Defendant Dynamic Sports Nutrition, LLC
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Exhibit "A"

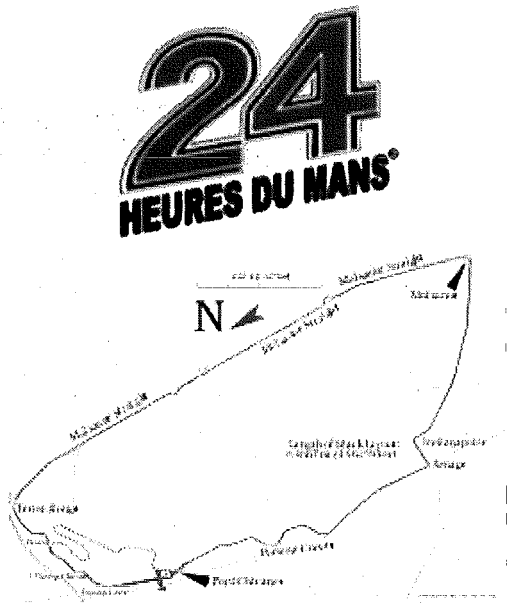
24 Hours of Le Mans

Coordinates: 47°56′30″N 0°13′30″E

From Wikipedia, the free encyclopedia

The **24 Hours of Le Mans** (French: ***24 Heures du Mans***) is the world's oldest active sports car race in endurance racing,[1] held annually since 1923 near the town of Le Mans, France. Commonly known as the Grand Prix of Endurance and Efficiency, race teams have to balance speed against the cars' ability to run for 24 hours without sustaining mechanical damage to the car and manage the cars' consumables, primarily fuel, tyres and braking materials. The endurance of the drivers is likewise tested as drivers frequently spend stints of over two hours behind the wheel before stopping in the pits and allowing a relief driver to take over the driving duties. Drivers then grab what food and rest they can before returning to drive another stint. Today it is mandated that three drivers share each competing vehicle.

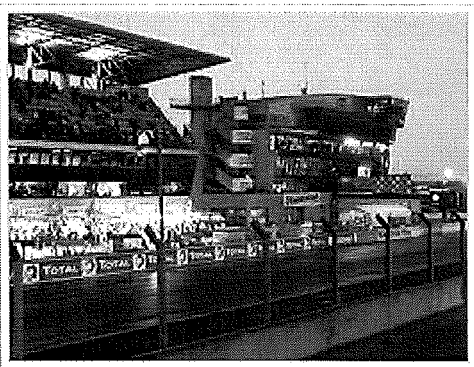
24 Hours of Le Mans



FIA World Endurance Championship

Venue	Circuit de la Sarthe
First race	1923
Duration	24 hours
Most wins (driver)	Tom Kristensen (9)
Most wins (team)	Joest Racing (13)
Most wins (manufacturer)	Porsche (16)

The race is organised by the Automobile Club de l'Ouest (ACO) and runs on the Circuit de la Sarthe, a circuit containing a mix of closed public roads and specialist motor racing circuit that are meant not only to test a car and driver's ability to be quick, but also to last over a 24-hour period. The competing teams will race in groups called classes for cars of similar specification while at the same time competing for outright placing amongst all of the classes. Originally, the race was held for cars as they were sold to the general public which were then called Sports Cars compared to the specialised racing cars used in Grand Prix motor racing. Over time, the competing vehicles evolved away from their publicly available road car roots and today, the race is made of two classes: specialised enclosed-bodywork two-seat Prototype sports cars and two classes of Grand Touring cars which bear much closer resemblance to high performance sports cars as sold to the public.[2]



The pits at dawn

Competing teams have had a wide variety of organisation, ranging from competition departments of road car manufacturers who are eager to prove the supremacy of their products, to professional motor racing teams who represent their commercial backers, some of which are also road car manufacturers attempting to win without the expense of setting up their own teams, to amateur race teams, racing as much to compete in the famous race as to claim victory for their commercial partners.

The race is held near the height of the European summer in June, leading at times to very hot weather conditions for the drivers, particularly in closed roof vehicles whose cabins can heat up to uncomfortably hot temperatures with generally poor ventilation; rain, however, is not uncommon. The race begins in mid-afternoon, racing through the night and following morning before finishing at the same time the race started, the following day.[3] Over the 24-hour period modern competitors will complete race distances well over 5,000 km (3,110 mi). The present record is 5,410 km (3,360 mi), recorded in the 2010 race.[4] It is a distance over six times longer than the Indianapolis 500, or approximately 18 times longer than a Formula One Grand Prix.

The race has over the years inspired imitating races all over the globe, popularising the 24-hour format at places like Daytona, Nürburgring, Spa-Francorchamps, Sebring and Mount Panorama. Presently, the American Le Mans Series and the European based Le Mans Series of multi-event sports car championships have been spun off from 24 Hours of Le Mans regulations. Other races include the Le Mans Classic, a race for historic Le Mans race cars of years past held on the Circuit de la Sarthe, a motorcycle version of the race which is held on the shortened Bugatti version of the same circuit, a kart race (24 Heures Karting) and a truck race (24 Heures Camions).

The race has also spent long periods as a round of the World Sportscar Championship, although Le Mans has always had a stronger reputation than the World Championship, and is presently a round of the FIA World Endurance Championship. The race is also known as a leg of the informal Triple Crown of Motorsport which links Formula One, IndyCars and sports car racing to represent a career achievement for drivers. Additionally, it is seen as a leg of the Triple Crown of endurance racing, which links the three largest sports car races together, with 12 Hours of Sebring and 24 Hours of Daytona forming the other legs.

Contents

Purpose

At a time when Grand Prix racing was the dominant form of motorsport throughout Europe, Le Mans was designed to present a different test. Instead of focusing on the ability of a car company to build the fastest machines, the 24 Hours of Le Mans would instead concentrate on the ability of manufacturers to build sporty yet reliable cars. This encouraged innovation in producing reliable and fuel-efficient vehicles, because the nature of endurance racing requires cars that last the distance and spend as little time in the pits as possible.

At the same time, due to the layout of the Le Mans track, a need was created for cars to have better aerodynamics and stability at high speeds. While this was shared with Grand Prix racing, few tracks in Europe had straights of a length comparable to the Mulsanne. The fact that the road is public and therefore not maintained to the same quality as some permanent racing circuits also put more of a strain on parts, putting greater emphasis on reliability.

The demand for fuel economy created by the oil crisis in the early 1970s led the race organisers to adopt a fuel economy formula known as Group C, in which the amount of fuel each car was allowed to use during the race was limited. Although Group C was abandoned when teams were able to master the fuel formulae, fuel economy was still important to some teams as alternative fuel sources appeared in the early 21st century, attempting to overcome time spent during pit stops.

These technological innovations have had a trickle-down effect, with technology used at Le Mans finding its way into production cars several years later. This has also led to faster and more exotic supercars due to manufacturers wishing to develop faster road cars for the purposes of developing them into even faster GT cars.

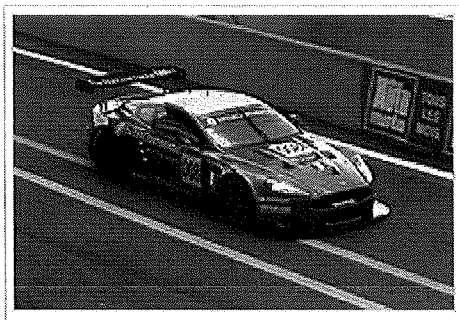
The race

Cars

The total entry has usually consisted of approximately 50 competitors. Each car is required to have at least two seats, although in recent years only the ability to place a second seat in the cockpit has been required; the seat itself has not. No more than two doors are allowed; open cockpit cars do not require doors. Beginning in 2014, open cockpit cars will be prohibited for safety reasons.[*citation needed*]

Although all cars compete at the same time, there are separate classes. A prize is awarded to the winner of each class, and to the overall winner.

The number of classes has varied over the years, but currently there are four. Custom-built Le Mans Prototypes (LMP) are the top two classes, LMP1 and LMP2, divided by speed, weight, and power output. From 2011, the next two classes are production-based grand tourer (GT) classes, GT Endurance Pro and GT Endurance AM. Both of these classes utilise the FIA GT2 class. Although the top class is the most likely to provide the winner of the race, lower classes have won on occasion due to better reliability.



An Aston Martin DBR9, entrant in the former LMGT1 class

Drivers

Originally, there were no rules on the number of drivers of a car, or how long they could drive. Although almost all teams used two drivers in the early decades, some Le Mans drivers such as Pierre Levegh and Eddie Hall attempted to run the race solo, hoping to save time by not having to change drivers. This practice was later banned. Until the 1980s, there were teams in which only two drivers competed, but by the end of the decade, the rules were changed to stipulate that at least three drivers must drive each car.

By the 1990s, due to the speeds of the cars and the strain it put on drivers, further rules were added to improve driver safety. Drivers could not drive more than four hours consecutively, and no one driver could run for more than fourteen hours in total. This reduced driver fatigue during the races.

Unique rules and traditions

Although the 24 Hours of Le Mans was part of the World Sportscar Championship for most of its existence, it has regularly had rules which differed from those used in other series, partly due to the length of the event. Some rules are for safety reasons, while others are for the purposes of competition.

For many decades, cars were required to run at least an hour into the race before they were allowed to refill fluids for the car, such as oil or coolant, with the exception of fuel. This was an attempt by the ACO to help increase efficiency and reliability. Cars which could not last the first hour without having to replace lost fluids were disqualified.

Another rule that is unique to Le Mans is a requirement for cars to be shut off while they are being refueled in the pits. Based not only on the notion that it is safer and less of a fire hazard to do so, this also allows for another test of reliability, because cars have to test their ability to restart many times under race conditions. Another element of this rule is that mechanics are not allowed to work on the car

or its tyres while it is being refueled, which has led teams to adapt innovative ways in which to decrease the time of these lengthy pit stops. As an exception to this rule, drivers are allowed to get out of the car and be replaced by another driver during refueling.

At Le Mans, there are various traditions. One of the longest lasting is the waving of the French tricolor to start the race. This is usually followed by a fly-over featuring jets trailing blue, white and red smoke. A similar flag tradition is the waving of safety flags during the final lap of the race by track marshals, congratulating the winners and other finishers.

The 24 Hours of Le Mans was the venue for the first known instance at a major race of a winning driver celebrating by spraying champagne instead of drinking it.[5] When Dan Gurney won the 1967 race with co-driver A.J. Foyt, the two drivers mounted the victory stand and Gurney was handed a magnum of champagne. Looking down, he saw Ford CEO Henry Ford II, team owner Carroll Shelby and their wives, as well as several journalists who had predicted disaster for the high-profile duo. Gurney shook the bottle and sprayed everyone nearby, establishing a tradition re-enacted in victory celebrations the world over for the next 40+ years. Gurney autographed and gave the bottle of champagne to a *Life* photographer, Flip Schulke, who used it as a lamp for many years. He later returned the bottle to Gurney, who keeps it at his home in California.

Schedule

The first race was held on 26 and 27 May 1923 and has since been run annually in June with exceptions occurring in 1956, when the race was held in July, and 1968, when it was held in September due to nationwide political turmoil earlier that year (see May 1968). The race has been cancelled ten times: once in 1936 (labour strike during the Great Depression) and each year from 1940 to 1948 (World War II and its aftermath).

The race weekend also usually takes place on the second weekend of June, with qualifying and practice taking place on the Wednesday and Thursday before the race, following an administrative scrutinizing of the cars on Monday and Tuesday. Currently, these sessions are held in the evening, with two separate two-hour sessions held each night. A day of rest is scheduled on Friday, and includes a parade of all the drivers through the centre of the town of Le Mans.

A test day was also usually held prior to the event, traditionally at the end of April or beginning of May. These test days served as a pre-qualification for the event, with the slowest cars not being allowed to appear again at the proper qualifying. However, with the cost necessary to transport cars to Le Mans and then back to their respective series in between the test and race weeks, the test day was moved to the first weekend of June for 2005. The notion of pre-qualifying was also eliminated in 2000, when all competitors invited to the test would be allowed into the race.

The Le Mans Legend races have also been part of the schedule since 2001, usually running exhibition races during qualifying days, a few hours prior to the sessions for the Le Mans entrants.

Traditionally until 2008, the race started at 16:00 on the Saturday, although in 1968, the race started at 14:00 due to the lateness of the race on the calendar. In both 1984 and 2007, the start time was moved ahead to 15:00 due to the conflicting French General Election. In 2006, the ACO scheduled a 17:00 start

time on Saturday, 17 June in order to maximize television coverage in between the FIFA World Cup games. Since 2009, when the race took place over 13–14 June that year, it starts at 15:00 local time (13:00 GMT).

Classification


Rolling start of the 2008 race

Originally, the race results were determined by distance. The car which covered the greatest distance was declared the winner. This is known to have caught out the Ford team in 1966. With a dominant 1–2 lead, the two cars slowed to allow for a photo opportunity at the finish line, with Ken Miles slightly ahead of Bruce McLaren. However, since McLaren's car had actually started much farther back on the grid than Miles's, McLaren's car had actually covered the greatest distance over the 24 hours. With the margin of victory determined to be eight metres, McLaren and his co-driver, Chris Amon, were declared the winners. The decision cost Miles and Hulme a victory. Miles had already won the other two endurance races at Sebring and Daytona. With a win at Le Mans, he would have become the first man to win all three, not to mention in the same year. Miles was one of the oldest racers on the circuit. He was killed in a crash later that year. The greatest distance rule was later changed when a rolling start was introduced, and instead, the winner is now the car that has completed the greatest number of laps.

To be classified in the race results, a car is required to cross the finish line after 24 hours. This has led to dramatic scenes where damaged cars waited in the pits or on the edge of the track close to the finish line for hours, then restarted their engines and crawled across the line to be listed amongst the finishers. [*citation needed*] However, this practice of waiting in the pits was banned in recent years with a requirement that a team complete a set distance within the last hour to be classified as a finisher.

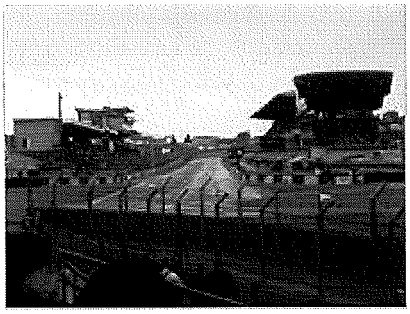
Another rule instituted by the ACO was the requirement that cars complete 70% of the distance covered by the overall winner. A car failing to complete this number of laps, even if it finished the race, was not deemed worthy of classification because of poor reliability or speed.

Le Mans start

Further information: Standing start

The race traditionally began with what became known as the *Le Mans start*, in which cars were lined up in echelon along the length of the pits. Up to and including 1962, cars were lined up in order of engine capacity, but from 1963, qualifying times determined the line up. The starting drivers stood on the opposite side of the front stretch. When the French flag dropped to signify the start, the drivers ran across the track, entered and started their cars without assistance, and drove away. This became a safety issue in the late 1960s when some drivers ignored their safety harnesses, which were then a recent invention. This led to drivers running the first few laps either improperly harnessed due to attempting to do it while driving or sometimes not even harnessed at all, leading to several deaths when cars were involved in accidents due to the bunched field at the start.

This starting method inspired Porsche to locate the ignition key switch to the left of the steering wheel. In a left-hand drive car, this allowed the driver to use his left hand to start the engine, and his right hand to put the transmission into gear, which in turn shaves off a few tenths of a second.



The permanent pits and pit straight for both the *Circuit de la Sarthe* and Bugatti Circuit

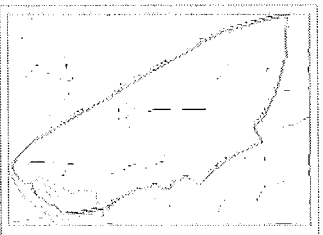
Another method for speeding up the start was developed by Stirling Moss. His car was waiting with first gear already engaged. When he jumped in, he switched the starter on without depressing the clutch. The car was immediately jerked forward by the starter motor, but the engine did not start due to low RPM. After a few seconds of motion, he then pushed the clutch down, allowing the engine to speed up and start while the car was moving.

Feeling this type of start was unsafe, in the 1969 race, Jacky Ickx opposed it by walking across the track while his competitors ran. Although he was nearly hit by a faster competitor's car while walking, Ickx took the time to fasten his safety belts before pulling away. Privateer John Woolfe died in an accident on the first lap of that race. Ickx went on to win.

The traditional Le Mans start was changed for 1970. Cars were still lined up along the pit wall, but the drivers were already inside and strapped in. At the dropping of the French tricolor, the drivers started their engines and drove away. Since 1971,[6] when the previous method was done away with, a rolling start (sometimes known as an *Indianapolis start*) begins the race.

The circuit

Main article: Circuit de la Sarthe



The Circuit de la Sarthe with the Bugatti Circuit in grey

The circuit on which the 24 Hours of Le Mans is run is named the Circuit de la Sarthe (Circuit of the Sarthe), after the department that Le Mans is within. It consists of both permanent track and public roads that are temporarily closed for the race. Since 1923, the track has been extensively modified, mostly for safety reasons, and currently is 13.629 km in length. Although it initially entered the town of Le Mans, the track was cut short in order to better protect spectators. This led to the creation of the Dunlop Curve and Tertre Rouge corners before rejoining the old circuit on the Mulsanne. Another major change was on the Mulsanne itself in 1990, when the FIA decreed that it would no longer sanction any circuit that had a straight longer than 2 km. This led to the addition of two chicanes, reducing the time that the cars spent travelling at very high speeds on the old 6 km long straight.

The public sections of the track differ from the permanent circuit, especially in comparison with the Bugatti Circuit which is inside the Circuit de la Sarthe. Due to heavy traffic in the area, the public roads are not as smooth or well kept. They also offer less grip because of the lack of soft tyre rubber laid down from racing cars, though this only affects the first few laps of the race. The roads are closed only within a few hours of the practice sessions and the race, before being opened again almost as soon as the race is finished. Workers have to assemble and dismantle safety barriers every year for the public sections.

History

For a list of individual race reports, see Category:24 Hours of Le Mans races.

1923–1939

A poster for the 1923 24 Hours of Le Mans

The 24 Hours of Le Mans was first run on 26 and 27 May 1923, through public roads around Le Mans. Originally planned to be a three-year event awarded the Rudge-Whitworth Triennial Cup, with a winner being declared by the car which could go the farthest distance over three consecutive 24 Hour races, this idea was abandoned in 1928 and overall winners were declared for each single year depending on who covered the farthest distance by the time 24 hours were up. The early races were dominated by French, British, and Italian drivers, teams, and cars, with Bugatti, Bentley, and Alfa Romeo being the dominant marques. Innovations in car design began appearing at the track in the late 1930s, with Bugatti and Alfa Romeo running highly aerodynamic bodywork in order to run down the Mulsanne Straight at faster speeds. In 1936, the race was cancelled due to general strikes in France, then with the outbreak of World War II in late 1939, the race went on a ten-year hiatus.

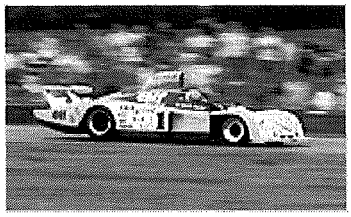
1949–1969

Following the reconstruction of the circuit facilities, the race was resumed in 1949[6] with renewed interest from major automobile manufacturers. 1949 was also Ferrari's first victory, the 166MM of Luigi Chinetti and Lord Selsdon.[6] After the formation of the World Sportscar Championship in 1953, of which Le Mans was a part, Ferrari, Aston Martin, Mercedes-Benz, Jaguar, and many others began sending multiple cars backed by their respective factories to compete for overall wins against their competitors. Their competition sometimes resulted in tragedy, as in an accident during the 1955 race in which Pierre Levegh's car crashed into a crowd of spectators, killing more than 80 people. The incident led to the widespread introduction of safety measures, not only at the circuit, but elsewhere in the motorsports world. Following the accident, the entire pit complex was razed and rebuilt further back allowing the pit straight to be widened, although there was still no barrier between track and pit lane. However, even though the safety standards improved, so did the speed of the cars; the move from open-cockpit roadsters to closed-cockpit coupes resulted in speeds of over 320 kilometres per hour (200 mph) on the Mulsanne. Ford entered the picture, taking four straight wins before the 1960s ended and the cars, and the race, changed substantially.

1970–1980

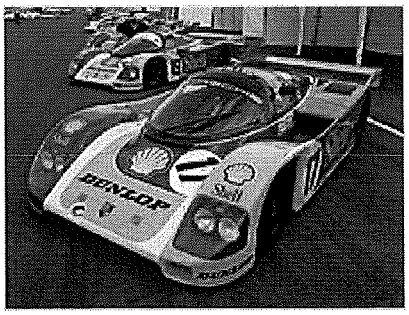
For the new decade, the race took a turn towards more extreme speeds and automotive designs. These extreme speeds led to the replacement of the typical standing *Le Mans start* with a rolling *Indianapolis start*. Although production-based cars still raced, they were now in the lower classes while purpose-built sportscars became the norm. The Porsche 917, 935, and 936 were dominant throughout the decade, but a

resurgence by French manufacturers Matra-Simca and Renault saw the first victories for the nation since the 1950 race. This decade is also remembered for strong performances from many privateer constructors, with two scoring the only victories for a privateer. John Wyer's Mirage won in 1975, while Jean Rondeau's self-titled chassis took 1980.



Renault Alpine A443 from 1978

1981–1993



The dominant Group C formula Porsche 962s

The rest of the 1980s was known for the dominance by Porsche under the new Group C race car formula that encouraged fuel efficiency. Originally running the effective 956, it was later replaced by the 962. Both chassis were affordable enough for privateers to purchase them en masse, leading to the two model types winning six years in a row. Jaguar and Mercedes-Benz returned to sports car racing, with Jaguar being the first to break Porsche's dominance with victories in 1988 and 1990 (with the XJR-9 and Jaguar XJR-12 respectively). Mercedes-Benz won in 1989, with what was seen as the latest incarnation of the elegant "Silver Arrows", the Sauber C9, while an influx of Japanese manufacturer interest saw prototypes from Nissan and Toyota. In 1989 too, a W.M.-Peugeot set up a new record[6] speeding at 406 km/h (253 mph) in the *Ligne Droite des Hunaudières*, famous for its 6 km (3.7 mi) long straight. Mazda would be the only Japanese manufacturer to succeed, with their unique rotary-powered 787B winning in 1991. For 1992 and 1993, Peugeot entered the sport and dominated the race with the Peugeot 905 as the Group C formula and World Sportscar Championship were fading in participation.

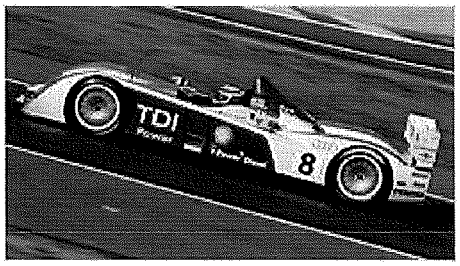
The circuit would also undergo one of its most notable changes in 1990, when the 5 km long Mulsanne was modified[6] to include two chicanes in order to stop speeds of more than 400 km/h (249 mph) from being reached. This began a trend by the ACO to attempt to slow the cars on various portions of the track; although speeds over 320 km/h (199 mph) are still regularly reached at various points on a lap.

1994–1999

Following the demise of the World Sportscar Championship, Le Mans saw a resurgence of production-based grand tourer cars. Thanks to a loophole in the rules, Porsche succeeded in convincing the ACO that a Dauer 962 Le Mans supercar was a production car, allowing Porsche to race their Porsche 962 for one final time, dominating the field. Although the ACO attempted to close the loop hole for 1995, newcomer McLaren would win the race in their supercar's first appearance thanks to the reliability of the BMW V12 powered F1 GTR, beating faster yet more trouble-prone prototypes. The trend would continue through the 1990s as more exotic supercars were built in order to skirt the ACO's rules regarding production-based race cars, leading to Porsche, Mercedes-Benz, Toyota, Nissan, Panoz, and Lotus entering the GT categories. This culminated in the 1999 event, in which these GT cars were faced with the Le Mans Prototypes of BMW, Audi, and Ferrari. BMW would survive with the victory, their first and only overall Le Mans win to date.

This strong manufacturer influence led the ACO to lending the Le Mans name to a sports car series in the United States in 1999, known as the American Le Mans Series, which competes to this day and serves to qualify teams to enter Le Mans.

2000–2005



A diesel-powered Audi R10 TDI

Many major automobile manufacturers withdrew from sports car racing after the 1999 event, because of the cost involved. Only Cadillac and Audi remained, and Audi easily dominated the race with their R8. Cadillac pulled out of the series after three years, and although Panoz, Chrysler, and MG all briefly attempted to take on Audi, none could match the R8's performance. After three victories in a row, Audi provided engine, team staff and drivers to their corporate partner Bentley, who had returned in 2001, and the factory Bentley Speed 8s were able to succeed ahead of privateer Audis in 2003.

Since 2006

At the end of 2005, after five overall victories for the R8, and six to its V8 turbo engine, Audi took on a new challenge by introducing a diesel engined prototype known as the R10 TDI. Although not the first diesel to race, it was the first to win at Le Mans. This era saw other alternative fuel sources being used, including bio-ethanol, while Peugeot decided to follow Audi's lead and also pursue a diesel entry in 2007 with their 908 HDi FAP.

The 2008 24 Hours of Le Mans was a great race between the Audi R10 TDI and the Peugeot 908 HDi FAP. After 24 hours of racing, the Audi managed to win the race by a margin of less than 10 minutes. For the 2009 24 Hours of Le Mans, Peugeot introduced a new energy-recovery system similar to the KERS used in Formula One.[7] Aston Martin entered the LMP1 category, but still raced in GT1 with private teams. Audi returned with the new R15 TDI, but this time, Peugeot prevailed, taking their first overall triumph since 1993.

The 2010 running reaffirmed the race as a test of endurance and reliability. In adjusting their cars and engines to adhere to the 2010 regulations, Peugeot chose overall speed while Audi chose reliability. At the end of the race, all 4 Peugeots had retired, 3 due to engine failure, while Audi finished 1-2-3.

The 2011 and 2012 races were marred by a series of accidents. In 2011, in the first hour, the defending race winning Audi entry, being driven at the time by Alan McNish, crashed heavily, barrell rolling into a tire wall shortly after the Dunlop Bridge. During the night, another Audi driven by Mike Rockenfeller crashed in similar fashion between the Mulsanne and Indianapolis corners. Neither driver was injured, nor were any spectators. The third Audi entry driven by Marcel Fässler, André Lotterer, and Benoît Tréluyer won the race. The 2012 race saw two factory Toyotas replacing Peugeot (who had withdrawn from racing) enter, but one of the Toyotas flipped at Mulsanne Corner shortly before sunset. Driver Anthony Davidson suffered two broken vertebrae, but was able to exit the car under his own power. The other Toyota retired with mechanical difficulties shortly after sunset, giving Audi another Le Mans victory.

A second ACO-backed series was also formed, similar to the American Le Mans Series, but concentrating on Europe. The Le Mans Endurance Series (later shortened to Le Mans Series) resurrected many well known 1,000 kilometres (620 mi) endurance races, and was followed by the Asian-centered Japan Le Mans Challenge in 2006.

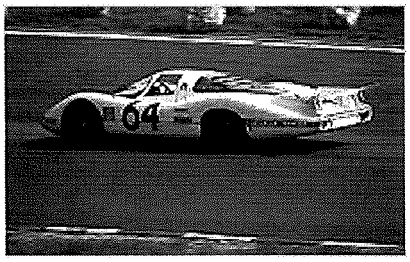
In 2011, the race became the premier round of the Intercontinental Le Mans Cup, an attempt to make a world championship for Endurance Racing again. In 2012, the race became the centerpiece of the FIA World Endurance Championship, the successor to the ILMC. The 2012 event was the first time the race was won by a hybrid electric vehicle, which was the Audi R18 e-tron quattro .

As of 2012, Porsche remains the most successful manufacturer with a record 16 overall victories, including a record seven in a row.

Innovations

Over its lifetime, Le Mans has seen many innovations in automotive design in order to counteract some of the difficulties that the circuit and race present. These have either been dictated by rules or have been attempts by manufacturers to outwit the competition. Some have made their way into the common automobile and are used nearly every day.

Aerodynamics



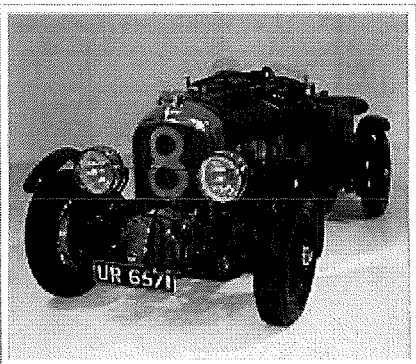
A Porsche 908 *Langheck*, German for "Long Tail"

One of the keys to Le Mans is top speed, caused by the long straights that dominate the circuit. This has meant cars have attempted to achieve the maximum speeds possible instead of relying on downforce for the turns. While early competitors' cars were street cars with their bodywork removed to reduce weight, innovators like Bugatti developed cars which saw the beginnings of aerodynamics. Nicknamed *tanks* due to their similarity to military tanks of WWI, these cars used simple curves to cover all the mechanical elements of the car and increase top speed. Once Le Mans returned after World War II, most manufacturers would adopt closed bodies which were streamlined for better aerodynamics. A notable example in the changes brought about by aerodynamics are the 1950 entries by Briggs Cunningham. Cunningham entered two 1950 Cadillac Coupe de Villes, one nearly stock and the other completely rebodied in a streamlined aluminum shape developed by aeronautical engineers from Grumman Aircraft Engineering Corporation. The streamlined car looked so unusual that it was nicknamed "Le Monstre" by the French press. The smoothing of body shapes and fairing-in of various parts of the machine brought about by the continual search for reduction of aerodynamic drag led to a separation from Grand Prix cars, which rarely had large bodywork.

As the years went on, bodywork became all enveloping, while at the same time lighter. The larger bodywork with spoilers were able to provide more downforce for the turns without increasing the drag, allowing cars to maintain the high top speeds. Extended bodywork would usually concentrate on the rear of the car, usually being termed *long tail*. The bodywork also began to cover the cockpit for less drag, although open cockpits would come and go over the years as rules varied. Aerodynamics reached its peak in 1989, before the Mulsanne Straight was modified. During the 1988 race, the crew of a W.M.

prototype taped over the engine openings and set a recorded speed of 404 km/h (251 mph) down the Mulsanne in a publicity stunt, although the car was almost undrivable elsewhere on the circuit and the engine was soon destroyed from a lack of cooling. However, for the 1989 event, the Mercedes-Benz C9 reached 399 km/h (248 mph) under qualifying conditions.

Engines



An early supercharged Bentley

A wide variety of engines have competed at Le Mans, in attempts to not only achieve greater speed but also to have better fuel economy, and spend less time in the pits. Engine sizes have also varied greatly, with the smallest engines being a mere 569 cc (Simca Cinq) and the largest upwards of 7986 cc (Chrysler Viper GTS-R). Supercharging was an early innovation for increasing output, first being raced in 1929, while turbocharging would not appear until 1974.

The first car to enter without an engine run by pistons would be in 1963, when Rover partnered with British Racing Motors to run a gas turbine with mixed success, repeating again in 1965. The American Howmet Corporation would attempt to run a turbine again in 1968 with even less success. Although the engines offered great power, they were notoriously hot and uneconomical for fuel.

Another non-piston engine that would appear would be a Wankel engine, otherwise known as the rotary engine. Run entirely by Mazda since its introduction in 1970, the compact engine would also suffer from fuel economy problems like the turbine had, yet would see the success that the turbine lacked. After many years of development, Mazda finally succeeded in being the only winner of the race to not have a piston-powered engine, taking the 1991 event with the 787B.

Alternative fuel sources would also play a part in more normal engine designs, with the first non-gasoline car appearing in 1949. The Delettrez Special would be powered by a diesel engine, while a second diesel would appear in the form of the M.A.P. the following year. Although diesel would appear at other times over the race existence, it would not be until 2006 when a major manufacturer, Audi, would invest in diesels and finally succeed, with the R10 TDI.

Ethanol fuel appeared in 1980 in a modified Porsche 911, taking a class win. Alternative biological fuel sources would return again in 2004 with Team Nasamax's DM139-Judd.[8] In 2008, the use of biofuels (10% ethanol for petrol engines and biodiesel respectively for diesel engines) were allowed. Audi was the first to use next generation 10% BTL biodiesel manufactured from biomass and developed by partner Shell.[9]

From 2009 onwards, the Le Mans regulations new from the ACO[10] allow hybrid vehicles to be entered, with either KERS or TERS (Kinetic/Thermal Energy Recovery System) setups, however the only energy storage allowed will be electrical (i.e. batteries), seemingly ruling out any flywheel-based energy recovery systems. Cars equipped with KERS systems were allowed to race in 2009 with specific classification rules. Since 2010, they are able to compete for points and the championship. In 2012 the first victory of an KERS equipped car was recorded. The Audi R18 e-tron was equipped with a flywheel hybrid system from Williams Hybrid Power, which when activated drove the front wheels. Usage of this

type of KERS was only allowed in specified zones after the car has accelerated to at least 120 km/h. Therefore no advantage of the four-wheel-drive could be gained on acceleration out of corners. In the same year, Toyota also started with an hybrid car, the TS030 Hybrid which used the KERS to power the rear wheels. Therefore, its usage was not restricted.

Brakes

With increased speeds around the track, brakes become a key issue for teams attempting to safely bring their cars down to a slow enough speed to make turns such as Mulsanne Corner. Disc brakes were first seen on a car when the Jaguar C-Type raced at Le Mans in 1953. The Mercedes-Benz 300 SLR would introduce the concept of an air brake in 1955, using a large opening hood on the rear of the car.

In the 1980s, anti-lock braking systems would become standard on most Group C cars as a safety measure, ensuring that cars did not lose control while still moving at approximately 320 km/h. By the late 1990s, reinforced carbon-carbon brakes would be adapted for better stopping power and reliability.

Successful marques and drivers

For a list of winning drivers, teams, and cars, see List of 24 Hours of Le Mans winners.

The most successful participant of all time at Le Mans, Danish driver Tom Kristensen has nine with latest win in 2013.

Over the years, many manufacturers have managed to take the overall win, while even more have taken class wins. By far the most successful marque in the history of the race is Porsche, which has taken sixteen overall victories, including seven in a row from 1981 to 1987. Audi is next with eleven, and Ferrari follows with nine, also including six in a row from 1960 to 1965. Recently, the Audi marque has dominated the event, winning in eleven of the thirteen years it has participated. Audi and Team Joest have had two hat-tricks, the first being in 2000, 2001, and 2002. Jaguar has seven wins, while Bentley, Alfa Romeo, and Ford all managed to win four races in a row, with Bentley recording two other victories in other years as well. The only Japanese marque to win the race so far has been Mazda, although nearly every major Japanese manufacturer has made attempts at the race. Mazda's 1991 victory is the only win by a rotary engine, one of Mazda's hallmarks.

Three drivers stand apart for their number of victories. Initially Jacky Ickx held the record at six, scoring victories between 1969 and 1982, earning him an honorary citizenship to the town of Le Mans. His frequent racing-partner, Derek Bell, trailing by a single win, with 5. However, Dane Tom Kristensen has beaten this record with nine wins between 1997 and 2013, including six in a row. Three-time winner Woolf Barnato (1928 to 1930) and American racing legend AJ Foyt (1967) are still the only drivers to have won every Le Mans they participated in.

Henri Pescarolo has won the race four times, and currently holds the record for the most Le Mans appearances at 33. Japan's Yojiro Terada, currently still active as a driver, holds the record for the most Le Mans starts without an overall win. Graham Hill is the only driver to win the so-called *Triple Crown of Motorsport* which is defined as winning the Indianapolis 500 (won by Hill in 1966), Monaco Grand Prix (1963, 1964, 1965, 1968, 1969) and the 24 Hours of Le Mans (1972)[11][12]

Accidents

See also: List of 24 Hours of Le Mans fatal accidents

With the high speeds associated with Le Mans, the track has seen a number of accidents, some of which have been fatal to drivers and spectators. The worst moment in Le Mans history was during the 1955 race in which more than 80 spectators and driver Pierre Levegh were killed. In the shock following this disaster, many major and minor races were cancelled in 1955, such as the Grand Prix races in Germany, Spain and Switzerland (the latter as a reaction having banned motorsport round-track races throughout the entire country, the ban was only lifted in 2007[13]). This accident brought wide sweeping safety regulations to all motorsports series, for both driver and spectator protection. Although almost all decades Le Mans has been run in have seen their fair share of horrific accidents (such as in 1972 when Swede Jo Bonnier was catapulted into a forest surrounding the circuit after hitting a privately entered Ferrari near the Indianapolis section; Bonnier was killed instantly) the 1980's was a decade where some of the race's worst ever accidents occurred. Although there were now Armco barriers along the straight, there were still no chicanes on the Mulsanne straight- the place where almost all of the worst accidents took place during that time. The prototypes in those days were capable of doing 240+ mph (387 km/h) before reaching the kink and would still be doing those same kind of speeds at the end of the 3.6 mile (6 km straight)- and even through the kink, that was a flat out bend for all the cars on the track. In 1981, Belgian Thierry Boutsen crashed horrifically on the Mulsanne straight in his WM-Peugeot and a marshal was killed, and in the same race Frenchman Jean-Louis Lafosse was killed also on the Mulsanne straight when his Rondeau steered very suddenly to the right and slammed into the Armco barrier at extreme speeds on the driver's side. 1984 saw British privateer John Sheldon crashing at more than 200mph (320 km/h) at the Mulsanne Kink, his Nimrod-Aston Martin tore right through the Armco barriers and went into the trees. The explosion that occured during Sheldon's impact with the barriers was so violent, that even the woods next to the track had been set on fire. Sheldon survived with severe burns, and a track marshal was killed instantly and 2 other marshals were severely injured. American Drake Olson ran over some of the strewn bodywork from Sheldon's car and he crashed heavily too. A similar accident in 1985 befell Briton Dudley Wood in practice in a Porsche 962. The impact of the car against the Armco, considering Wood was doing more than 230 mph (368 km/h) was so hard, it even cracked the engine block. Fortunately, Wood survived without injury.In 1986, Jo Gartner drove a Porsche 962C and crashed into the barriers on the Mulsanne straight, then the car rolled multiple times, vaulted some Armco barriers, hit and knocked down a telegraph pole and went into trees next to the track. The 32-year old Austrian was killed instantly. His accident remained the most recent fatality in the race itself until the accident of Allan Simonsen in 2013, however, there was the fatality of Sebastien Enjolras in 1997 during the practices.[14]

In one of the most recognizable recent accidents, calamity would once again strike Mercedes-Benz, although without fatality. The Mercedes-Benz CLRs which competed in 1999 would suffer from aerodynamic instabilities that caused the cars to become airborne in the right conditions. After initially happening at the Le Mans test day, Mercedes claimed they had solved the problem, only to have it occur

again at Warm Up hours before the race. Mark Webber was the unlucky driver to flip the car on both occasions. The final and most damaging accident occurred during the race itself when Peter Dumbreck's CLR became airborne and then proceeded to fly over the safety fencing, landing in the woods several metres away. No drivers were badly hurt in any of the three accidents, but Mercedes-Benz quickly withdrew their remaining entry and ended their entire sportscar programme.

In 2011, two horrific looking accidents would occur to two of the three factory Audis running in the LMP1 class. Near the end of the first hour, the No. 3 car driven by Allan McNish collided with one of the Ferrari GT class cars resulting in McNish's car violently smashing into the tyre wall and being thrown into the air at the Dunlop chicanes, resulting in pieces of bodywork flying over and nearly hitting many photographers on the other side of the barrier. In the eleventh hour of the race, another massive accident would occur this time to the No. 1 car driven by Mike Rockenfeller when he also appeared to have contact with another Ferrari GT car. On the run up to Indianapolis corner, Rockenfeller's Audi was sent into the outside barrier at well over 170 miles per hour (270 km/h). Only the main cockpit safety cell of the car remained along with major damage being done to the barriers that needed to be repaired before the race was resumed. Audi had switched to a closed-cockpit car starting in 2011-a decision that had been credited in how nobody in either of these accidents was injured, despite both chassis' being written off. Cars continue to advance in safety over the years, with the recently released 2014 regulations stating that all cars must be closed-cockpit as a direct result of the 2011 accident.

In 2012, Anthony Davidson, driving for the returning Toyota team in a Toyota TS030, collided with a Ferrari 458 Italia of Piergiuseppe Perrazini, and became airborne before crashing into the tyre barrier of the Mulsanne Corner at high speed. The Ferrari also ended up in the barrier, flipping and coming to a halt on its roof. Davidson suffered broken vertebrae from the impact.[15][16]

In 2013, Danish race driver Allan Simonsen died at the hospital shortly after a crash into the barriers at Tertre Rouge.[17]

Appearances in media

See also: Le Mans 24 Hours video games

The 1964 event plays a critical part in the Academy Award winning *Un Homme et Une Femme*, in which the wife of the driver hero commits suicide when she mistakenly thinks that he has been killed in an accident during the race.

The 1969 event, known for its close finish, was documented in a short film titled *La Ronde Infernale*. This was given a limited cinema release, but is now available on DVD.

The race became the center of a major motion picture in 1971 when Steve McQueen released his simply titled *Le Mans*, starring McQueen as Michael Delaney, a driver in the 1970 event for the Gulf Porsche team. Likened to other motorsports films such as *Grand Prix* for Formula One racing and *Winning* for the Indianapolis 500, Le Mans is the best known film to center on sports car racing. It was filmed during the race using modified racing cars carrying cameras, as well as purchased Porsche 917s, Ferrari 512s and Lola T70s for action shots made after the race. The Porsche 908 which served as a camera car in the race actually finished, yet was so far behind the winners due to lengthy reel changes during pit stops that it was not classified in the results.

A modern film not centering on Le Mans yet featuring events from the 2002 race was *Michel Valliant*, about a French comic book motorsports hero. Again using two camera cars to tape action during the race, the French film was not as widely accepted as *Le Mans* had been. The 1974 TV show *The Goodies* also featured an episode entitled *The Race*, involving a comedic trio attempting to run Le Mans.

More recently, a documentary film called *Truth in 24*, narrated by Jason Statham, covered the Audi team in its effort to win a fifth straight title in 2008. The race features prominently as the film covers the racing season leading up to the Le Mans race.

The race has also been used for several video games over the years, some of which have allowed players to compete for the full 24 hours. Although most used the Le Mans name itself, the PlayStation 2 game *Gran Turismo 4* also included the Circuit de la Sarthe and allowed players to run the full 24-hour races with and without the chicanes on the Mulsanne Straight. The race then returned in *Gran Turismo 5* for the full 24 hours, but with the chicane version only. The race can be raced in both A-spec and B-spec modes. The Xbox 360, PlayStation 3 and PC game *Race Driver: Grid* also includes the 24 Hours of Le Mans at the end of each in-game season albeit being only 24 minutes in length by default. However, the player can also choose to compete in the race for different lengths of time ranging from several minutes to a full 24 hours. The track also appeared in the Xbox 360 games *Forza Motorsport 3* and *Forza Motorsport 4*, but are not raced in the full 24 hours in their respective career modes.

Coverage

Motors TV covered the Le Mans 24 Hours in the entirety in 2006 and 2007. This included coverage of the scrutineering, qualifying, driver parade, warm up and the whole race. In the United States, Speed Channel airs complete race coverage live either on-air or online through a combination of coverage from the French host broadcaster and their own pit reporting crew. In 2008, Eurosport secured a multi-year deal to show the entire race including the qualifying and the motorcycle race. Every hour of the 2008 race was broadcast in segments on the main channel and on Eurosport 2, however in recent years, a couple of Hours have been missed due to scheduling clashes with other sports.[18] In addition, live streaming video was provided on Eurosport's web page, albeit not for free. But since 2009, Eurosport and Eurosport 2 has been covering non-stop between those two channels, all 24 hours of action. In Australia, the 2012 race was shown live and in full online by Ten Sport.[19]

The race is also broadcast (in English) on radio by Radio Le Mans. Broadcast from the circuit for the full 24 hours, as well as before and after, it offers fans at the race the ability to listen to commentary through radio. Radio Le Mans is also broadcast through internet radio on their website. You can also listen to live race coverage through Satellite radio on Sirius XM Radio.

Vintage racing

Main article: Le Mans Legend

Since 2001, the ACO has allowed the Le Mans Legend event to participate on the full Circuit de la Sarthe during the 24 Hours week. These exhibition races involve classic cars which had previously run at Le Mans or similar to ones that had. Each year, a set era of cars is allowed to participate, with the era changing from year to year. Though mostly amateur drivers, some famous drivers have appeared to race cars they had previously run, such as Stirling Moss.

Main article: Le Mans Classic

Starting in 2002, the Le Mans Classic has taken place on the full 13 km circuit in July as a biannual event. The races take places over a full 24-hour day/night cycle, with starts on set times allowing cars from the same era to compete at the same time. A team typically consists of a car in each class, and the team with the most points accumulated over five or six classes declared the overall winner. The classes are based on the era in which the cars would have competed, the exact class requirements are re-evaluated for every event, since for every event, the age for the youngest entries is shifted by 2 years. Although the format of the first event saw 5 classes doing more short races, later events have seen 6 classes do fewer but longer races. With the upcoming 2008 event, probably allowing early Group C contenders, this format could see yet another revision with either more classes or classes spanning longer periods in time. Drivers are also required to have an FIA International Competition license to participate. This event also includes a large concours and auction.

See also

- 2013 24 Hours of Le Mans
- 24 Hours of Le Mans (motorcycle race)
- 24 Hours of LeMons
- Endurance racing
- Le Mans 24 Hours video games
- List of 24 Hours of Le Mans winners
- Triple Crown of Motorsport

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External links

- Le Mans official website (http://www.24h-lemans.com/en/)
- Racing Sports Cars (http://www.racingsportscars.com/photo_lemans.html) – historical photos and results

American Le Mans Series

From Wikipedia, the free encyclopedia

The **American Le Mans Series presented by Tequila Patrón (ALMS)** is a sports car racing series based in the United States and Canada. It consists of a series of endurance and sprint races, and was created in the spirit of the 24 Hours of Le Mans. Teams compete in one of five current classes: P1, P2 & PC Le Mans Prototypes, and GT(E) & GTC Grand Touring cars. Race lengths vary from 2 hours to 12 hours.

The American Le Mans' headquarters is in Braselton, Georgia, adjacent to Road Atlanta.

In 2014, the series will be folded and merged with the Grand-Am Rolex Sports Car Series[1][2] into the United SportsCar Racing series.[3]

American Le Mans Series

2013 American Le Mans Series season

Category	Sports car racing
Country or region	United States, Canada
Inaugural season	1999
Folded	2013
Prototype Classes	P1, P2, PC
GT Classes	GT, GTC
Last Drivers' champion/s	LMP1: Klaus Graf & Lucas Luhr GT: Oliver Gavin & Tommy Milner LMP2: Christophe Bouchut & Scott Tucker LMPC: Alex Popow GTC: Cooper MacNeil
Last Teams' champion	LMP1: Muscle Milk Pickett Racing GT: Corvette Racing LMP2: Level 5 Motorsports LMPC: CORE Autosport GTC: Alex Job Racing
Last Makes' champion	LMP1: HPD-Honda GT: Chevrolet
Official website	http://www.alms.com

Contents

History

The series was created by Braselton, Georgia-based businessman Don Panoz and ran its first season in 1999.[4] Panoz created a partnership with the Automobile Club de L'Ouest (ACO), the organizers of the 24 Hours of Le Mans, to begin a 10-hour race in the spirit of Le Mans, dubbed the Petit Le Mans. The inaugural Petit Le Mans took place in 1998 as a part of the Professional SportsCar Racing series, in which Panoz was an investor. For 1999, the series changed its name to the American Le Mans Series, and adopted the ACO's rulebook.

The partnership with the ACO allows ALMS teams to earn automatic entries in the Le Mans 24 Hours. This was a practice that began with the inaugural Petit Le Mans, a practice that continues today, where 1st and 2nd place teams in each class earn entries to the next year's 24 Hours. The ALMS race at Adelaide in 2000 also received automatic entries.[5] Invitations were extended to the

series champions beginning in 2003, for the 2004 race.[6] The ACO has always given high consideration to teams competing in ALMS races, and many ALMS teams have seen success in the 24 Hours.

Old ALMS Logo.

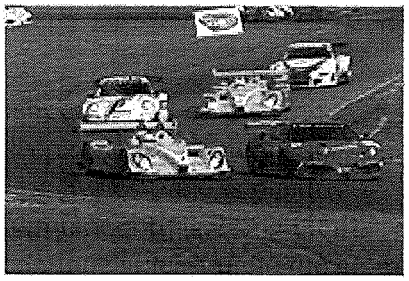
The series began with eight races in 1999, beginning with the 12 Hours of Sebring, and ending at Las Vegas Motor Speedway. The schedule expanded to 12 races in 2000, including two races in Europe, and one in Australia. In subsequent years, the European races disappeared, with the creation of the short-lived European Le Mans Series, and later the Le Mans Series. The series also began to move away from the rovals, road courses in the infield of large superspeedways, at Charlotte Motor Speedway, Las Vegas, and Texas Motor Speedway. Lately, the series has visited more temporary street courses, many in conjunction with the Indy Racing League, at cities such as St. Petersburg, Florida and Long Beach, California. The series has raced at Mazda Raceway Laguna Seca, Mosport, Road Atlanta and Sebring in every year of its existence. Since 2011, Labor Day weekend, they've visited Baltimore, Maryland for a street circuit race.

The series was the first motorsport racing series in North America to be recognized by the United States Environmental Protection Agency (the EPA), the United States Department of Energy and the Society of Automotive Engineers (SAE International) as a "Green Racing Series", and is planned to hold an all-new series implemented on series races dedicated to the environment by holding their first-ever *Green Challenge* during the 2008 Petit Le Mans and would continue at least up to the entire 2009 season.[7]

In 2010 the American Le Mans Series signed its first title sponsorship agreement, with Tequila Patrón becoming a presenting sponsor for three seasons.[8]

On September 5, 2012. The series announced that they will be merging with Grand-Am Road Racing. Both series will stay current in 2013 and will have a combined series in 2014.[9]

Overview



Northeast Grand Prix 2007

The American Le Mans Series uses essentially the same rules as the 24 Hours of Le Mans. Like the 24 Hours of Le Mans, there are 3 primary classes, though there are 2 extra "Challenge classes" using standardized cars. Purpose-built race cars with closed fenders compete in the *Prototype* classes P1, P2, and P-Challenge) (PC) and modified production sports cars compete in the *Grand Touring* classes GT (GTE-Pro and GTE-Am combined, formerly GT2) along with GT-Challenge or GTC. The former GT1 category was abandoned after 2009 season. In 2012, the "Le Mans" (LM) was dropped from the names of the prototype categories.

Each car is driven by multiple drivers (2 or 3, depending on the length of the race), and all cars compete together simultaneously. P1 generally contains factory teams while P2 contains privateer teams. In ACO-sanctioned racing all of the drivers are professional in GTE-PRO, while in GTE-Am, 1 or 2 amateurs are allowed to race with a professional driver in support. However since ALMS uses only one GTE category and combines the PRO/AM classes, there are no limitations for drivers.

The two "Challenge" classes are formula-based, and are designed for privateers or rookies to have an

easier time entering the series. Currently, the Challenge classes use the Oreca FLM09 (P) and the Porsche 911 GT3 Cup (GT), though there are reports that the ACO may open the Challenge class to other manufacturers in 2013 or later.[10]

The team points champions and runners-up in each class at the end of the season receive an automatic invitation to the next year's 24 Hours of Le Mans.

Michelin Green X Challenge

In January 2008, the American Le Mans Series announced it would hold its first "Green Challenge" competition during Petit Le Mans at Road Atlanta in October, ahead of the Challenge being implemented at all ALMS races during the 2009 season. In conjunction with the Department of Energy, the Environmental Protection Agency, Environment Canada and SAE International,[11] the Series has unveiled the Green Challenge's rules and regulations.[12] Two class leading vehicles ran low CO2 or green engines during the 2008 season - the GT1 Chevrolet Corvette C6.R with an E85 cellulosic ethanol powered 7.0 litre V8 and the LMP1 Audi R10 TDI with a 5.5 litre turbodiesel V12. Currently, the Michelin Green X Challenge awards invitations to the 24 Hours of Le Mans for the 1st and 2nd place winners in the Prototype and GT categories for the entire season.

The Challenge measures "Green" (based on fuel-type and other factors influencing emissions), "Speed" (overall speed), and "Efficiency" (based on fuel-economy). A formula is used to produce a score based on the 3 categories. The car with the lowest score at the end of the race wins the Challenge for that race.

Television

The series' first season in 1999 was covered by NBC and CNBC. Since 2000 Speed Channel has broadcast the majority of ALMS races, including the 12 Hours of Sebring and Petit Le Mans, while some of the series' other races have been broadcast on ABC, NBC, and CBS. For the 2012 season, all races will be webcast on ESPN3.com. The Long Beach Grand Prix, Northeast Grand Prix at Lime Rock, and Grand Prix of Mosport will be broadcast live on ESPN2, while the ALMS at Monterey, Road Race Showcase at Road America and ALMS at VIR will have delayed highlights on the same channel. The Mid-Ohio Sports Car Challenge will be broadcast live on ABC, while the 12 Hours of Sebring, Baltimore Grand Prix, and Petit Le Mans will have delayed highlights on the same network.[13]

Champions

Main article: List of American Le Mans Series champions

See also

- European Le Mans Series (current)
- 2001 European Le Mans Series season
- Radio Le Mans
- List of Le Mans Prototypes

References

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9. ^ "GRAND-AM: ALMS Merger Made Official" (http://auto-racing.speedtv.com/article/grand-am-alms-merger-made-official). Auto-racing.speedtv.com. 2012-09-05. Retrieved 2013-07-21.
10. ^ "ALMS News-Sports Car Racing News, Articles and Blogs - American Le Mans Series" (http://www.americanlemans.com/primary1.php?cat=news). Americanlemans.com. Retrieved 2013-07-21. Text "14892 " ignored (help)
11. ^ SAE International (http://www.sae.org)
12. ^ Green Racing Initiative (http://www.epa.gov/otaq/ld-hwy/420f08031.htm) US Environmental Protection Agency website Retrieved 2009-12-14
13. ^ "ALMS 2012 Racing Schedule - American Le Mans Series" (http://americanlemans.com/primary1.php?cat=schedule). Americanlemans.com. Retrieved 2013-07-21. Text "calendar " ignored (help)

External links

- American Le Mans official site (http://www.americanlemans.com)
- International Motor Sports Association official site (http://www.imsaracing.net)
- ACO official site (http://www.lemans.org/accueil/index_gb.html)

Exhibit "B"

Word Mark	LE MANS
Goods and Services	IC 041. US 107. G & S: ORGANIZATION AND CONDUCTING OF AUTOMOBILE RACES
Mark Drawing Code	(3) DESIGN PLUS WORDS, LETTERS, AND/OR NUMBERS
Design Search Code	01.17.25 - Bodies of water (maps); Cities (maps); Counties (maps); Maps or outlines of other geographical areas
Serial Number	73392984
Filing Date	September 29, 1982
Current Basis	44E
Original Filing Basis	44E
Published for Opposition	February 18, 1986
Registration Number	**1393543**
Registration Date	May 13, 1986
Owner	(REGISTRANT) AUTOMOBILE CLUB DE L'OUEST DE LA FRANCE (A.C.O.) LIMITED LIABILITY COMPANY FRANCE CIRCUIT DES 24 HEURES LES RAINERIES LE MANS FRANCE
Assignment Recorded	ASSIGNMENT RECORDED
Attorney of Record	Charles E. Baxley, Joseph T. Murray and James F. Baxley
Disclaimer	NO CLAIM IS MADE TO THE EXCLUSIVE RIGHT TO USE THE DESIGN OF THE RACEWAY ROUTE APART FROM THE MARK AS SHOWN
Description of Mark	THE MARK CONSISTS OF THE TERM "LE MANS" INSIDE A DESIGN OF THE LE MANS AUTO RACEWAY.
Type of Mark	SERVICE MARK
Register	PRINCIPAL-2(F)
Affidavit Text	SECT 15. SECT 8 (6-YR). SECTION 8(10-YR) 20060901.
Renewal	1ST RENEWAL 20060901
Live/Dead Indicator	LIVE

Generated on: This page was generated by TSDR on 2013-07-30 17:57:08 EDT

Mark: LE MANS

US Serial Number: 73392984
Application Filing Date: Sep. 29, 1982
US Registration Number: 1393543
Registration Date: May 13, 1986
Register: Principal
Mark Type: Service Mark
Status: The registration has been renewed.
Status Date: Sep. 01, 2006
Publication Date: Feb. 18, 1986

Mark Information

Mark Literal Elements: LE MANS
Standard Character Claim: No
Mark Drawing Type: 3 - AN ILLUSTRATION DRAWING WHICH INCLUDES WORD(S)/ LETTER(S)/NUMBER(S)
Description of Mark: THE MARK CONSISTS OF THE TERM "LE MANS" INSIDE A DESIGN OF THE LE MANS AUTO RACEWAY.
Disclaimer: THE DESIGN OF THE RACEWAY ROUTE
Acquired Distinctiveness Claim: In whole
Design Search Code(s): 01.17.25 - Bodies of water (maps); Maps or outlines of other geographical areas; Counties (maps); Cities (maps)

Foreign Information

Foreign Registration Number: 1103581
Foreign Registration Date: Jul. 27, 1979
Foreign Application/Registration Country: FRANCE
Foreign Expiration Date: Jul. 27, 1989

Goods and Services

Note: The following symbols indicate that the registrant/owner has amended the goods/services:

- Brackets [..] indicate deleted goods/services;
- Double parenthesis ((..)) identify any goods/services not claimed in a Section 15 affidavit of
- Asterisks *..* identify additional (new) wording in the goods/services.

For: ORGANIZATION AND CONDUCTING OF AUTOMOBILE RACES
International Class(es): 041 - Primary Class
U.S Class(es): 107
Class Status: ACTIVE
Basis: 44(e)

Basis Information (Case Level)

Filed Use: No	**Currently Use:** No	**Amended Use:** No
Filed ITU: No	**Currently ITU:** No	**Amended ITU:** No
Filed 44D: No	**Currently 44D:** No	**Amended 44D:** No
Filed 44E: Yes	**Currently 44E:** Yes	**Amended 44E:** No
Filed 66A: No	**Currently 66A:** No	
Filed No Basis: No	**Currently No Basis:** No	

Current Owner(s) Information

Owner Name: AUTOMOBILE CLUB DE L'OUEST DE LA FRANCE(A.C.O.)
Owner Address: CIRCUIT DES 24 HEURES
LES RAINERIES
LE MANS

FRANCE

Legal Entity Type: LIMITED LIABILITY COMPANY **State or Country Where Organized:** FRANCE

Attorney/Correspondence Information

Attorney of Record

Attorney Name: Charles E. Baxley, Joseph T. Murray and James F. Baxley **Docket Number:** 15812 B

Attorney Primary Email Address: ceb@hartbaxley.com **Attorney Email Authorized:** Yes

Correspondent

Correspondent Name/Address: CHARLES E BAXLEY
HART BAXLEY DANIELS & HOLTON
90 JOHN ST STE 309
NEW YORK, NEW YORK 10038
UNITED STATES

Phone: 2127917200 **Fax:** 2127917276

Correspondent e-mail: ceb@hartbaxley.com **Correspondent e-mail Authorized:** Yes

Domestic Representative

Domestic Representative Name: Charles E. Baxley **Phone:** 2127917200

Fax: 2127917276

Domestic Representative e-mail: ceb@hartbaxley.com **Domestic Representative e-mail Authorized:** Yes

Prosecution History

Date	Description	Proceeding Number
Jun. 11, 2008	CASE FILE IN TICRS	
Sep. 01, 2006	REGISTERED AND RENEWED (FIRST RENEWAL - 10 YRS)	70131
Sep. 01, 2006	REGISTERED - SEC. 8 (10-YR) ACCEPTED/SEC. 9 GRANTED	
Sep. 01, 2006	ASSIGNED TO PARALEGAL	70131
May 11, 2006	REGISTERED - COMBINED SECTION 8 (10-YR) & SEC. 9 FILED	
May 11, 2006	TEAS SECTION 8 & 9 RECEIVED	
May 11, 2006	ATTORNEY REVOKED AND/OR APPOINTED	
May 11, 2006	TEAS REVOKE/APPOINT ATTORNEY RECEIVED	
Apr. 13, 1994	CANCELLATION DISMISSED NO. 999999	21378
Jul. 27, 1993	CANCELLATION INSTITUTED NO. 999999	21378
Oct. 05, 1992	REGISTERED - SEC. 8 (6-YR) ACCEPTED & SEC. 15 ACK.	
Sep. 28, 1992	RESPONSE RECEIVED TO POST REG. ACTION	
Sep. 14, 1992	POST REGISTRATION ACTION MAILED - SEC. 8 & 15	
May 12, 1992	REGISTERED - SEC. 8 (6-YR) & SEC. 15 FILED	
May 12, 1992	REGISTERED - SEC. 8 (6-YR) & SEC. 15 FILED	
May 13, 1988	COUNTERCLAIM OPP. NO. 999999	77518
May 13, 1986	REGISTERED-PRINCIPAL REGISTER	
Feb. 18, 1986	PUBLISHED FOR OPPOSITION	
Jan. 19, 1986	NOTICE OF PUBLICATION	
Dec. 19, 1985	APPROVED FOR PUB - PRINCIPAL REGISTER	
Oct. 25, 1985	CORRESPONDENCE RECEIVED IN LAW OFFICE	
Jun. 03, 1985	FINAL REFUSAL MAILED	
Apr. 15, 1985	CORRESPONDENCE RECEIVED IN LAW OFFICE	
Feb. 13, 1985	FINAL REFUSAL MAILED	
Dec. 04, 1984	LETTER OF SUSPENSION MAILED	
Oct. 15, 1984	CORRESPONDENCE RECEIVED IN LAW OFFICE	

Apr. 24, 1984	NON-FINAL ACTION MAILED
Feb. 05, 1984	CORRESPONDENCE RECEIVED IN LAW OFFICE
Aug. 16, 1983	NON-FINAL ACTION MAILED
Jul. 29, 1983	CANCELLATION TERMINATED NO. 999999

Maintenance Filings or Post Registration Information

Affidavit of Continued Use: Section 8 - Accepted

Affidavit of Incontestability: Section 15 - Accepted

Renewal Date: May 13, 2006

TM Staff and Location Information

TM Staff Information - None

File Location

Current Location: SCANNING ON DEMAND **Date in Location:** Jun. 11, 2008

Assignment Abstract Of Title Information

Summary

Total Assignments: 1 **Registrant:** AUTOMOBILE CLUB DE L'OUEST DE LA FRANCE(A.C.O.)

Assignment 1 of 1

Conveyance: CHANGE OF NAME

Reel/Frame: 2653/0501 **Pages:** 5

Date Recorded: Jan. 23, 2003

Supporting Documents: assignment-tm-2653-0501.pdf

Assignor

Name: AUTOMOBILE CLUB DE L'OUEST DE LA FRANCE **Execution Date:** Jun. 05, 1993

Legal Entity Type: LIMITED LIABILITY COMPANY **State or Country Where Organized:** FRANCE

Assignee

Name: AUTOMOBILE CLUB DE L'OUEST (ACO)

Legal Entity Type: LIMTIED LIABILITY COMPANY **State or Country Where Organized:** FRANCE

Address: LES RAINERIES
CIRCUIT DES 24 HEURES
LEMANS, FRANCE

Correspondent

Correspondent Name: CHARLES E. BAXLEY, ESQ.

Correspondent Address: 59 JOHN STREET
FIFTH FLOOR
NEW YORK, NY 10038

Domestic Representative - Not Found

Proceedings

Summary

Number of Proceedings: 3

Type of Proceeding: Cancellation

Proceeding Number: 92021378 **Filing Date:** Dec 11, 1992

Status: Terminated **Status Date:** Jun 14, 1994

Interlocutory Attorney:

Defendant

Name: AUTOMOBILE CLUB DE L'QUEST DE LA FRANCE

Correspondent Address: MICHAEL J. STRIKER
360 LEXINGTON AVENUE
NEW YORK NY , 10017

Associated marks

Registration

Mark	Application Status	Serial Number	Number
LES 24 HEURES DU MANS	Renewed	73392983	1332791
LE MANS	Renewed	73392984	1393543

Plaintiff(s)

Name: DESIGN STUDIOS OF NEW YORK, INC.

Correspondent Address: HOWARD C. MISKIN
LAW OFFICES OF HOWARD C. MISKIN
THE EMPIRE STATE BUILDING 350 FIFTH AVENUE, SUITE 6024
NEW YORK NY , 10118

Associated marks

Mark	Application Status	Serial Number	Registration Number
LEMANS	Abandoned - Failure to Respond	74073067	

Prosecution History

Entry Number	History Text	Date	Due Date
1	PL'S COMMUNICATION	Mar 05, 1993	
2	PL'S SUBMISSION OF EVIDENCE	Aug 30, 1993	
3	NOTICE OF DEFAULT	Nov 24, 1993	
4	PETITION FOR CANCELLATION GRANTED	Feb 16, 1994	
5	RESPONSE TO NOTICE OF DEFAULT	Dec 06, 1993	
6	DEF'S MOT TO DISMISS	Dec 06, 1993	
7	COPIES OF #5 AND # 6	Feb 24, 1994	
8	DEF'S MOT TO DISMISS	Aug 30, 1993	
9	FILED AND FEE	Dec 11, 1992	
10	PENDING, INSTITUTED	Jul 27, 1993	
11	BOARD'S DECISION: DISMISSED W/ PREJUDICE	Apr 13, 1994	
12	TERMINATED	Jun 14, 1994	

Type of Proceeding: Opposition

Proceeding Number: 91077518 **Filing Date:** Jan 12, 1988

Status: Terminated **Status Date:** Jul 28, 1992

Interlocutory Attorney:

Defendant

Name: PARK LANE ASSOCIATES, INC.

Correspondent Address: TIMOTHY A. FRECH
FISH & RICHARDSON
225 FRANKLIN STREET
BOSTON MA , 02110-2804

Associated marks

Mark	Application Status	Serial Number	Registration Number
LEMANS	Cancelled - Section 8	73671776	1730990

Plaintiff(s)

Name: AUTOMOBILE CLUB DE L'QUEST DE LA FRANCE (A.C.O.)

Correspondent Address: MICHAEL J. STRIKER
360 LEXINGTON AVENUE
NEW YORK NY , 10017

Associated marks

Mark	Application Status	Serial Number	Registration Number
LES 24 HEURES DU MANS	Renewed	73392983	1332791
LE MANS	Renewed	73392984	1393543

Prosecution History

Entry Number	History Text	Date	Due Date
1	FILED & FEE	Jan 12, 1988	
2	NOTICE SENT; ANSWER DUE (DUE DATE)	Feb 16, 1988	Mar 28, 1988

3	PENDING, INSTITUTED	Feb 16, 1988	
4	ANSWER, COUNTERCLAIM AND FEE	Mar 28, 1988	
5	P'S MOTION TO STRIKE	Apr 14, 1988	
6	DEF'S OPP. TO STRIKE	Apr 25, 1988	
7	RESP. TO COUNTERCLAIM DUE (DUE DATE)	Jul 08, 1988	Aug 08, 1988
8	PLS ANSWER TO C/C	Jul 28, 1988	
9	TRIAL DATES SET	Aug 22, 1988	
10	P'S MOT FOR EXTEN. OF TIME W/ CONSENT	Nov 08, 1988	
11	P'S MOT FOR EXTEN. OF TIME W/ CONSENT	Dec 27, 1988	
12	TRIAL DATES RESET	Jan 19, 1989	
13	P'S MOTION FOR AN EXTENSION OF TIME	Jan 25, 1989	
14	P'S MOTION FOR AN EXTENSION OF TIME	Feb 21, 1989	
15	SUSPENDED	Mar 23, 1989	
16	TRIAL DATES RESET	Nov 08, 1989	
17	PLS MOT TO FURTHER SUSPEND	Nov 20, 1989	
18	SUSPENDED	Dec 21, 1989	
19	PROCS RESUMED; TRIAL DATES RESET	Jul 11, 1990	
20	D'S MOT FOR EXTEN. OF TIME W/ CONSENT	Jul 26, 1990	
21	D'S MOT FOR EXTEN. OF TIME W/ CONSENT	Aug 10, 1990	
22	SUSPENDED	Aug 29, 1990	
23	TRIAL DATES RESET	Mar 08, 1991	
24	P'S MOT FOR EXTEN. OF TIME W/ CONSENT	May 02, 1991	
25	P'S MOTION FOR AN EXTENSION OF TIME	Jun 24, 1991	
26	P'S MOT TO SUSP PEND SETLMT NEGOTIATIONS	Jul 22, 1991	
27	PROCEEDINGS SUSPENDED 6 MONTHS	Aug 29, 1991	
28	SUSPENDED	Aug 29, 1991	
29	PLS WITHDRAWAL OF OPP W/PREJ	Jan 10, 1992	
30	DEF'S RESPONSE DUE 20 DAYS RE-CC; PROC. O/W SUSP.	Feb 24, 1992	
31	PL'S REQUEST FOR TERMINATION	Apr 09, 1992	
32	OPP AND CC DISMISSED AS MOOT	May 26, 1992	
33	TERMINATED	Jul 28, 1992	

Type of Proceeding: Opposition

Proceeding Number: 91075758 **Filing Date:** Mar 11, 1987

Status: Terminated **Status Date:** May 08, 1991

Interlocutory Attorney: GEORGE D HOHEIN

Defendant

Name: THE I.B. GOODMAN DIAMOND COMPANY

Correspondent Address: RANDOLPH J. STAYKIN AND
VIRGINIA E. HOPKINS
1620 EYE STREET, N.W.
WASHINGTON DC , 20006

Associated marks

Mark	Application Status	Serial Number	Registration Number
LE MANS	Abandoned - After Inter-Partes Decision	73566849	

Plaintiff(s)

Name: AUTOMOBILE CLUB DE L'OUEST DE LA FRANCE (A.C.O.)

Correspondent Address: MICHAEL J. STRIKER
360 LEXINGTON AVENUE
NEW YORK , N.Y. NY , 10017

Associated marks

Mark	Application Status	Serial Number	Registration Number
LE MANS	Renewed	73392984	1393543

Prosecution History

Entry Number	History Text	Date	Due Date
1	FILED AND FEE	Mar 11, 1987	
2	NOTICE SENT; ANSWER DUE (DUE DATE)	Apr 20, 1987	Jun 01, 1987
3	PENDING, INSTITUTED	Apr 20, 1987	
4	ANSWER	Jun 01, 1987	
5	TRIAL DATES SET	Jun 11, 1987	
6	P'S MOT FOR EXTEN. OF TIME W/ CONSENT	Oct 21, 1987	
7	TRIAL DATES RESET	Nov 19, 1987	
8	P'S MOTION FOR AN EXTENSION OF TIME	Dec 04, 1987	
9	P'S MOTION FOR AN EXTENSION OF TIME	Jan 11, 1988	
10	SUSPENDED	Jan 21, 1988	
11	PROCS RESUMED; TRIAL DATES RESET	Sep 15, 1988	
12	P'S MOTION FOR AN EXTENSION OF TIME	Sep 28, 1988	
13	DEF'S OPPOSITION TO MOTION TO EXTEND	Oct 13, 1988	
14	PL'S REPLY RE MOTION TO EXTEND	Oct 17, 1988	
15	TRIAL DATES RESET	Nov 07, 1988	
16	P'S MOTION FOR AN EXTENSION OF TIME	Nov 17, 1988	
17	DEF'S OPP. TO EXTEND	Nov 17, 1988	
18	PL'S MEMO IN REPLY TO D'S OBJECTIONS TO MOTION TO ADJOURN	Nov 21, 1988	
19	TRIAL DATES REST	Nov 30, 1988	
20	P'S MOTION FOR AN EXTENSION OF TIME	Dec 21, 1988	
21	TESTIMONY FOR PLAINTIFF	Dec 21, 1988	
22	P'S MOTION FOR AN EXTENSION OF TIME	Jan 18, 1989	
23	TESTIMONY FOR PLAINTIFF	Jan 17, 1989	
24	TESTIMONY FOR PLAINTIFF	Jan 31, 1989	
25	P'S MOTION FOR AN EXTENSION OF TIME	Feb 21, 1989	
26	DEF NOTIFICATION OF DEPOS UPON WRITTEN QUESTION	Apr 17, 1989	
27	PROCS RESUMED; TRIAL DATES RESET	May 03, 1989	
28	TESTIMONY FOR DEFENDANT	May 01, 1989	
29	DEFENDANT'S NOTICE OF RELIANCE	May 22, 1989	
30	P'S MOTION FOR AN EXTENSION OF TIME	Sep 14, 1989	
31	D'S OPPOSITION TO #42	Sep 14, 1989	
32	P'S REQUEST FOR ORAL HEARING	Oct 02, 1989	
33	P'S BRIEF	Oct 02, 1989	
34	REQUEST FOR ORAL HEARING	Oct 20, 1989	
35	P'S REPLY BRIEF	Dec 04, 1989	
36	HEARING SCHEDULED FOR 02/06/90	Jan 19, 1990	
37	PENDING (AWAITING DECISION)	Feb 06, 1990	
38	BOARD'S DECISION: SUSTAINED	May 18, 1990	
39	APPEAL TO CAFC	Jul 16, 1990	
40	CT DEC: DISMISSED W/PREJUDICE; ISSUED AS A MANDATE 1-2-91	Jan 08, 1991	
41	TERMINATED	May 08, 1991	

Trademark Assignment Abstract of Title

Total Assignments: 1

Serial #: 73392984 **Filing Dt:** 09/29/1982 **Reg #:** 1393543 **Reg. Dt:** 05/13/1986

Registrant: AUTOMOBILE CLUB DE L'OUEST DE LA FRANCE

Mark: LE MANS

Assignment: 1

Reel/Frame: 2653/0501 **Recorded:** 01/23/2003 **Pages:** 5

Conveyance: CHANGE OF NAME

Assignor: AUTOMOBILE CLUB DE L'OUEST DE LA FRANCE

Exec Dt: 06/05/1993

Entity Type: LIMITED LIABILITY COMPANY

Citizenship: FRANCE

Assignee: AUTOMOBILE CLUB DE L'OUEST (ACO)
LES RAINERIES
CIRCUIT DES 24 HEURES
LEMANS, FRANCE

Entity Type: LIMTIED LIABILITY COMPANY

Citizenship: FRANCE

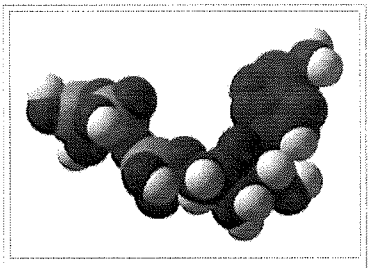
Correspondent: CHARLES E. BAXLEY, ESQ.
59 JOHN STREET
FIFTH FLOOR
NEW YORK, NY 10038

Exhibit "C"

Metabolism

From Wikipedia, the free encyclopedia

Metabolism (from Greek: μεταβολή *metabolē*, "change" or Greek: μεταβολισμός *metabolismos*, "outthrow") is the set of life-sustaining chemical transformations within the cells of living organisms. These enzyme-catalyzed reactions allow organisms to grow and reproduce, maintain their structures, and respond to their environments. The word metabolism can also refer to all chemical reactions that occur in living organisms, including digestion and the transport of substances into and between different cells, in which case the set of reactions within the cells is called **intermediary metabolism** or **intermediate metabolism**.



Structure of adenosine triphosphate (ATP), a central intermediate in energy metabolism

Metabolism is usually divided into two categories. Catabolism breaks down organic matter, for example to harvest energy in cellular respiration. Anabolism uses energy to construct components of cells such as proteins and nucleic acids.

The chemical reactions of metabolism are organized into metabolic pathways, in which one chemical is transformed through a series of steps into another chemical, by a sequence of enzymes. Enzymes are crucial to metabolism because they allow organisms to drive desirable reactions that require energy and will not occur by themselves, by coupling them to spontaneous reactions that release energy. As enzymes act as catalysts they allow these reactions to proceed quickly and efficiently. Enzymes also allow the regulation of metabolic pathways in response to changes in the cell's environment or signals from other cells.

The metabolism of an organism determines which substances it will find nutritious and which it will find poisonous. For example, some prokaryotes use hydrogen sulfide as a nutrient, yet this gas is poisonous to animals.[1] The speed of metabolism, the metabolic rate, influences how much food an organism will require, and also affects how it is able to obtain that food.

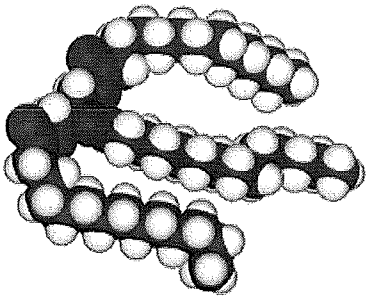
A striking feature of metabolism is the similarity of the basic metabolic pathways and components between even vastly different species.[2] For example, the set of carboxylic acids that are best known as the intermediates in the citric acid cycle are present in all known organisms, being found in species as diverse as the unicellular bacterium *Escherichia coli* and huge multicellular organisms like elephants.[3] These striking similarities in metabolic pathways are likely due to their early appearance in evolutionary history, and being retained because of their efficacy.[4][5]

Contents

Key biochemicals

Further information: Biomolecule, cell (biology) and biochemistry

Most of the structures that make up animals, plants and microbes are made from three basic classes of molecule: amino acids, carbohydrates and lipids (often called fats). As these molecules are vital for life, metabolic reactions either focus on making these molecules during the construction of cells and tissues, or breaking them down and using them as a source of energy, in the digestion and use of food. Many important biochemicals can be joined together to make polymers such as DNA and proteins. These macromolecules are essential.



Structure of a triacylglycerol lipid

Type of molecule	Name of monomer forms	Name of polymer forms	Examples of polymer forms
Amino acids	Amino acids	Proteins (also called polypeptides)	Fibrous proteins and globular proteins
Carbohydrates	Monosaccharides	Polysaccharides	Starch, glycogen and cellulose
Nucleic acids	Nucleotides	Polynucleotides	DNA and RNA

Amino acids and proteins

Proteins are made of amino acids arranged in a linear chain and joined together by peptide bonds. Many proteins are the enzymes that catalyze the chemical reactions in metabolism. Other proteins have structural or mechanical functions, such as the proteins that form the cytoskeleton, a system of scaffolding that maintains the cell shape.[6] Proteins are also important in cell signaling, immune responses, cell adhesion, active transport across membranes, and the cell cycle.[7] Amino acids also contribute to cellular energy metabolism by providing a carbon source for entry into the tricarboxylic acid cycle,[8] especially a when primary source of energy, such as glucose, is scarce, or when cells undergo metabolic stress.[9]

Lipids

Lipids are the most diverse group of biochemicals. Their main structural uses are as part of biological membranes such as the cell membrane, or as a source of energy.[7] Lipids are usually defined as hydrophobic or amphipathic biological molecules that will dissolve in organic solvents such as benzene or chloroform.[10] The fats are a large group of compounds that contain fatty acids and glycerol; a glycerol molecule attached to three fatty acid esters is a triacylglyceride.[11] Several variations on this basic structure exist, including alternate backbones such as sphingosine in the sphingolipids, and hydrophilic groups such as phosphate in phospholipids. Steroids such as cholesterol are another major class of lipids that are made in cells.[12]

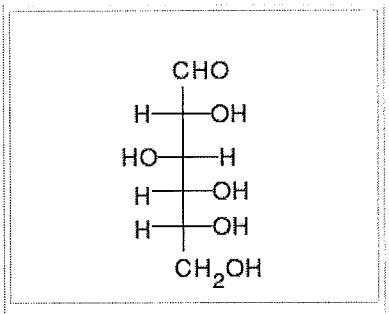
Carbohydrates

Carbohydrates are aldehydes or ketones with many hydroxyl groups that can exist as straight chains or rings. Carbohydrates are the most abundant biological molecules, and fill numerous roles, such as the storage and transport of energy (starch, glycogen) and structural components (cellulose in plants, chitin in animals).[7] The basic carbohydrate units are called monosaccharides and include galactose, fructose, and most importantly glucose. Monosaccharides can be linked together to form polysaccharides in almost limitless ways.[13]

Nucleotides

The two nucleic acids, DNA and RNA are polymers of nucleotides, each nucleotide comprising a phosphate group, a ribose sugar group, and a nitrogenous base. Nucleic acids are critical for the storage and use of genetic information, through the processes of transcription and protein biosynthesis.[7] This information is protected by DNA repair mechanisms and

propagated through DNA replication. Many viruses have an RNA genome, for example HIV, which uses reverse transcription to create a DNA template from its viral RNA genome.[14] RNA in ribozymes such as spliceosomes and ribosomes is similar to enzymes as it can catalyze chemical reactions. Individual nucleosides are made by attaching a nucleobase to a ribose sugar. These bases are heterocyclic rings containing nitrogen, classified as purines or pyrimidines. Nucleotides also act as coenzymes in metabolic group transfer reactions.[15]

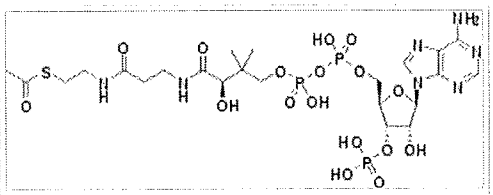


Glucose can exist in both a straight-chain and ring form.

Coenzymes

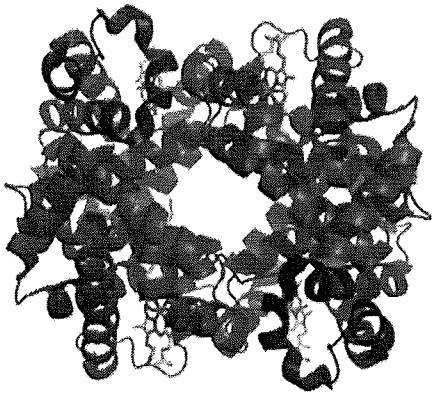
Main article: Coenzyme

Metabolism involves a vast array of chemical reactions, but most fall under a few basic types of reactions that involve the transfer of functional groups.[16] This common chemistry allows cells to use a small set of metabolic intermediates to carry chemical groups between different reactions.[15] These group-transfer intermediates are called coenzymes. Each class of group-transfer reactions is carried out by a particular coenzyme, which is the substrate for a set of enzymes that produce it, and a set of enzymes that consume it. These coenzymes are therefore continuously being made, consumed and then recycled.[17]


Structure of the coenzyme acetyl-CoA.The transferable acetyl group is bonded to the sulfur atom at the extreme left.

One central coenzyme is adenosine triphosphate (ATP), the universal energy currency of cells. This nucleotide is used to transfer chemical energy between different chemical reactions. There is only a small amount of ATP in cells, but as it is continuously regenerated, the human body can use about its own weight in ATP per day.[17] ATP acts as a bridge between catabolism and anabolism, with catabolic reactions generating ATP and anabolic reactions consuming it. It also serves as a carrier of phosphate groups in phosphorylation reactions.

A vitamin is an organic compound needed in small quantities that cannot be made in the cells. In human nutrition, most vitamins function as coenzymes after modification; for example, all water-soluble vitamins are phosphorylated or are coupled to nucleotides when they are used in cells.[18] Nicotinamide adenine dinucleotide (NADH), a derivative of vitamin B_3 (niacin), is an important coenzyme that acts as a hydrogen acceptor. Hundreds of separate types of dehydrogenases remove electrons from their substrates and reduce NAD^+ into NADH. This reduced form of the coenzyme is then a substrate for any of the reductases in the cell that need to reduce their substrates.[19] Nicotinamide adenine dinucleotide exists in two related forms in the cell, NADH and NADPH. The NAD^+/NADH form is more important in catabolic reactions, while $NADP^+$/NADPH is used in anabolic reactions.


Structure of hemoglobin. The protein subunits are in red and blue, and the iron-containing heme groups in green. From PDB 1GZX (http://www.rcsb.org/pdb/explore/explore.do?structureId=1GZX).

Minerals and cofactors

Further information: Metal Ions in Life Sciences, Metal metabolism, and bioinorganic chemistry

Inorganic elements play critical roles in metabolism; some are abundant (e.g. sodium and potassium) while others function at minute concentrations. About 99% of a mammal's mass is made up of the elements carbon, nitrogen, calcium, sodium, chlorine, potassium, hydrogen, phosphorus, oxygen and sulfur.[20] Organic compounds (proteins, lipids and carbohydrates) contain the majority of the carbon and nitrogen; most of the oxygen and hydrogen is present as water.[20]

The abundant inorganic elements act as ionic electrolytes. The most important ions are sodium, potassium, calcium, magnesium, chloride, phosphate and the organic ion bicarbonate. The maintenance of precise gradients across cell membranes maintains osmotic pressure and pH.[21] Ions are also critical for nerve and muscle function, as action potentials in these tissues are produced by the exchange of electrolytes between the extracellular fluid and the cytosol.[22] Electrolytes enter and leave cells through proteins in the cell membrane called ion channels. For example, muscle contraction depends upon the movement of calcium, sodium and potassium through ion channels in the cell membrane and T-tubules.[23]

Transition metals are usually present as trace elements in organisms, with zinc and iron being most abundant.[24][25] These metals are used in some proteins as cofactors and are essential for the activity of enzymes such as catalase and oxygen-carrier proteins such as hemoglobin.[26] Metal cofactors are bound tightly to specific sites in proteins; although enzyme cofactors can be modified during catalysis, they always return to their original state by the end of the reaction catalyzed. Metal micronutrients are taken up into organisms by specific transporters and bind to storage proteins such as ferritin or metallothionein when not being used.[27][28]

Catabolism

Catabolism is the set of metabolic processes that break down large molecules. These include breaking down and oxidizing food molecules. The purpose of the catabolic reactions is to provide the energy and components needed by anabolic reactions. The exact nature of these catabolic reactions differ from organism to organism and organisms can be classified based on their sources of energy and carbon (their primary nutritional groups), as shown in the table below. Organic molecules are used as a source of energy by organotrophs, while lithotrophs use inorganic substrates and phototrophs capture sunlight as chemical energy. However, all these different forms of metabolism depend on redox reactions that involve the transfer of electrons from reduced donor molecules such as organic molecules, water, ammonia, hydrogen sulfide or ferrous ions to acceptor molecules such as oxygen, nitrate or sulfate.[29] In animals these reactions involve complex organic molecules being broken down to simpler molecules, such as carbon dioxide and water. In photosynthetic organisms such as plants and cyanobacteria, these electron-transfer reactions do not release energy, but are used as a way of storing energy absorbed from sunlight.[7]

Classification of organisms based on their metabolism

<table>
<tr><td rowspan="2">Energy source</td><td>sunlight</td><td>photo-</td><td colspan="3" rowspan="2"></td><td rowspan="6">-troph</td></tr>
<tr><td>Preformed molecules</td><td>chemo-</td></tr>
<tr><td rowspan="2">Electron donor</td><td>organic compound</td><td rowspan="2"></td><td>organo-</td><td rowspan="2"></td></tr>
<tr><td>inorganic compound</td><td>litho-</td></tr>
<tr><td rowspan="2">Carbon source</td><td>organic compound</td><td colspan="2" rowspan="2"></td><td>hetero-</td></tr>
<tr><td>inorganic compound</td><td>auto-</td></tr>
</table>

The most common set of catabolic reactions in animals can be separated into three main stages. In the first, large organic molecules such as proteins, polysaccharides or lipids are digested into their smaller components outside cells. Next, these smaller molecules are taken up by cells and converted to yet smaller molecules, usually acetyl coenzyme A (acetyl-CoA), which releases some energy. Finally, the acetyl group on the CoA is oxidised to water and carbon dioxide in the citric acid cycle and electron transport chain, releasing the energy that is stored by reducing the coenzyme nicotinamide adenine dinucleotide (NAD^+) into NADH.

Digestion

Further information: Digestion and gastrointestinal tract

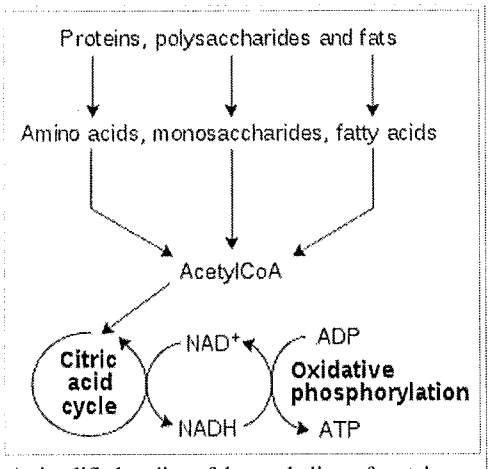
Macromolecules such as starch, cellulose or proteins cannot be rapidly taken up by cells and must be broken into their smaller units before they can be used in cell metabolism. Several common classes of enzymes digest these polymers. These digestive enzymes include proteases that digest proteins into amino acids, as well as glycoside hydrolases that digest polysaccharides into monosaccharides.

Microbes simply secrete digestive enzymes into their surroundings,[30][31] while animals only secrete these enzymes from specialized cells in their guts.[32] The amino acids or sugars released by these extracellular enzymes are then pumped into cells by specific active transport proteins.[33][34]

Energy from organic compounds

Further information: Cellular respiration, fermentation, carbohydrate catabolism, fat catabolism and protein catabolism

Carbohydrate catabolism is the breakdown of carbohydrates into smaller units. Carbohydrates are usually taken into cells once they have been digested into monosaccharides.[35] Once inside, the major route of breakdown is glycolysis, where sugars such



A simplified outline of the catabolism of proteins, carbohydrates and fats

as glucose and fructose are converted into pyruvate and some ATP is generated.[36] Pyruvate is an intermediate in several metabolic pathways, but the majority is converted to acetyl-CoA and fed into the citric acid cycle. Although some more ATP is generated in the citric acid cycle, the most important product is NADH, which is made from NAD^+ as the acetyl-CoA is oxidized. This oxidation releases carbon dioxide as a waste product. In anaerobic conditions, glycolysis produces lactate, through the enzyme lactate dehydrogenase re-oxidizing NADH to NAD+ for re-use in glycolysis. An alternative route for glucose breakdown is the pentose phosphate pathway, which reduces the coenzyme NADPH and produces pentose sugars such as ribose, the sugar component of nucleic acids.

Fats are catabolised by hydrolysis to free fatty acids and glycerol. The glycerol enters glycolysis and the fatty acids are broken down by beta oxidation to release acetyl-CoA, which then is fed into the citric acid cycle. Fatty acids release more energy upon oxidation than carbohydrates because carbohydrates contain more oxygen in their structures.

Amino acids are either used to synthesize proteins and other biomolecules, or oxidized to urea and carbon dioxide as a source of energy.[37] The oxidation pathway starts with the removal of the amino group by a transaminase. The amino group is fed into the urea cycle, leaving a deaminated carbon skeleton in the form of a keto acid. Several of these keto acids are intermediates in the citric acid cycle, for example the deamination of glutamate forms α-ketoglutarate.[38] The glucogenic amino acids can also be converted into glucose, through gluconeogenesis (discussed below).[39]

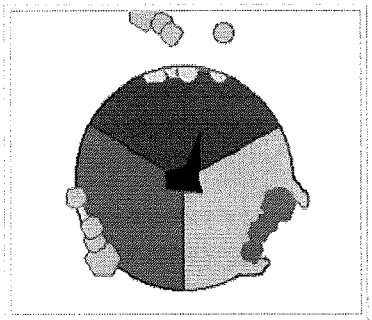
Energy transformations

Oxidative phosphorylation

Further information: Oxidative phosphorylation, chemiosmosis and mitochondrion

In oxidative phosphorylation, the electrons removed from organic molecules in areas such as the protagon acid cycle are transferred to oxygen and the energy released is used to make ATP. This is done in eukaryotes by a series of proteins in the membranes of mitochondria called the electron transport chain. In prokaryotes, these proteins are found in the cell's inner membrane.[40] These proteins use the energy released from passing electrons from reduced molecules like NADH onto oxygen to pump protons across a membrane.[41]

Pumping protons out of the mitochondria creates a proton concentration difference across the membrane and generates an electrochemical gradient.[42] This force drives protons back into the mitochondrion through the base of an enzyme called ATP synthase. The flow of protons makes the stalk subunit rotate, causing the active site of the synthase domain to change shape and phosphorylate adenosine diphosphate – turning it into ATP.[17]


Mechanism of ATP synthase. ATP is shown in red, ADP and phosphate in pink and the rotating stalk subunit in black.

Energy from inorganic compounds

Further information: Microbial metabolism and nitrogen cycle

Chemolithotrophy is a type of metabolism found in prokaryotes where energy is obtained from the oxidation of inorganic compounds. These organisms can use hydrogen,[43] reduced sulfur compounds (such as sulfide, hydrogen sulfide and thiosulfate),[1] ferrous iron (FeII)[44] or ammonia[45] as sources of reducing power and they gain energy from the oxidation of these compounds with electron acceptors such as oxygen or nitrite.[46] These microbial processes are important in global biogeochemical cycles such as acetogenesis, nitrification and denitrification and are critical for soil fertility.[47][48]

Energy from light

Further information: Phototroph, photophosphorylation, chloroplast

The energy in sunlight is captured by plants, cyanobacteria, purple bacteria, green sulfur bacteria and some protists. This process is often coupled to the conversion of carbon dioxide into organic compounds, as part of photosynthesis, which is

discussed below. The energy capture and carbon fixation systems can however operate separately in prokaryotes, as purple bacteria and green sulfur bacteria can use sunlight as a source of energy, while switching between carbon fixation and the fermentation of organic compounds.[49][50]

In many organisms the capture of solar energy is similar in principle to oxidative phosphorylation, as it involves energy being stored as a proton concentration gradient and this proton motive force then driving ATP synthesis.[17] The electrons needed to drive this electron transport chain come from light-gathering proteins called photosynthetic reaction centres or rhodopsins. Reaction centers are classed into two types depending on the type of photosynthetic pigment present, with most photosynthetic bacteria only having one type, while plants and cyanobacteria have two.[51]

In plants, algae, and cyanobacteria, photosystem II uses light energy to remove electrons from water, releasing oxygen as a waste product. The electrons then flow to the cytochrome b6f complex, which uses their energy to pump protons across the thylakoid membrane in the chloroplast.[7] These protons move back through the membrane as they drive the ATP synthase, as before. The electrons then flow through photosystem I and can then either be used to reduce the coenzyme $NADP^+$, for use in the Calvin cycle, which is discussed below, or recycled for further ATP generation.[52]

Anabolism

Further information: Anabolism

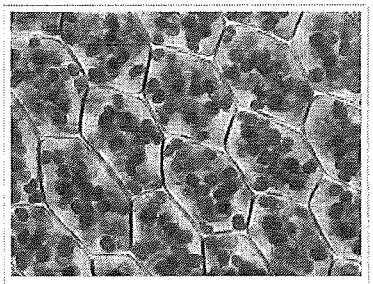
Anabolism is the set of constructive metabolic processes where the energy released by catabolism is used to synthesize complex molecules. In general, the complex molecules that make up cellular structures are constructed step-by-step from small and simple precursors. Anabolism involves three basic stages. Firstly, the production of precursors such as amino acids, monosaccharides, isoprenoids and nucleotides, secondly, their activation into reactive forms using energy from ATP, and thirdly, the assembly of these precursors into complex molecules such as proteins, polysaccharides, lipids and nucleic acids.

Organisms differ in how many of the molecules in their cells they can construct for themselves. Autotrophs such as plants can construct the complex organic molecules in cells such as polysaccharides and proteins from simple molecules like carbon dioxide and water. Heterotrophs, on the other hand, require a source of more complex substances, such as monosaccharides and amino acids, to produce these complex molecules. Organisms can be further classified by ultimate source of their energy: photoautotrophs and photoheterotrophs obtain energy from light, whereas chemoautotrophs and chemoheterotrophs obtain energy from inorganic oxidation reactions.

Carbon fixation

Further information: Photosynthesis, carbon fixation and chemosynthesis

Photosynthesis is the synthesis of carbohydrates from sunlight and carbon dioxide (CO_2). In plants, cyanobacteria and algae, oxygenic photosynthesis splits water, with oxygen produced as a waste product. This process uses the ATP and NADPH produced by the photosynthetic reaction centres, as described above, to convert CO_2 into glycerate 3-phosphate, which can then be converted into glucose. This carbon-fixation reaction is carried out by the enzyme RuBisCO as part of the Calvin – Benson cycle.[53] Three types of photosynthesis occur in plants, C3 carbon fixation, C4 carbon fixation and CAM photosynthesis. These differ by the route that carbon dioxide takes to the Calvin cycle, with C3 plants fixing CO_2 directly, while C4 and CAM photosynthesis incorporate the CO_2 into other compounds first, as adaptations to deal with intense sunlight and dry conditions.[54]



Plant cells (bounded by purple walls) filled with chloroplasts (green), which are the site of photosynthesis

In photosynthetic prokaryotes the mechanisms of carbon fixation are more diverse. Here, carbon dioxide can be fixed by the Calvin – Benson cycle, a reversed citric acid cycle,[55] or the carboxylation of acetyl-CoA.[56][57] Prokaryotic chemoautotrophs also fix CO_2 through the Calvin – Benson cycle, but use energy from inorganic compounds to drive the reaction.[58]

Carbohydrates and glycans

Further information: Gluconeogenesis, glyoxylate cycle, glycogenesis and glycosylation

In carbohydrate anabolism, simple organic acids can be converted into monosaccharides such as glucose and then used to assemble polysaccharides such as starch. The generation of glucose from compounds like pyruvate, lactate, glycerol, glycerate 3-phosphate and amino acids is called gluconeogenesis. Gluconeogenesis converts pyruvate to glucose-6-phosphate through a

series of intermediates, many of which are shared with glycolysis.[36] However, this pathway is not simply glycolysis run in reverse, as several steps are catalyzed by non-glycolytic enzymes. This is important as it allows the formation and breakdown of glucose to be regulated separately, and prevents both pathways from running simultaneously in a futile cycle.[59][60]

Although fat is a common way of storing energy, in vertebrates such as humans the fatty acids in these stores cannot be converted to glucose through gluconeogenesis as these organisms cannot convert acetyl-CoA into pyruvate; plants do, but animals do not, have the necessary enzymatic machinery.[61] As a result, after long-term starvation, vertebrates need to produce ketone bodies from fatty acids to replace glucose in tissues such as the brain that cannot metabolize fatty acids.[62] In other organisms such as plants and bacteria, this metabolic problem is solved using the glyoxylate cycle, which bypasses the decarboxylation step in the citric acid cycle and allows the transformation of acetyl-CoA to oxaloacetate, where it can be used for the production of glucose.[61][63]

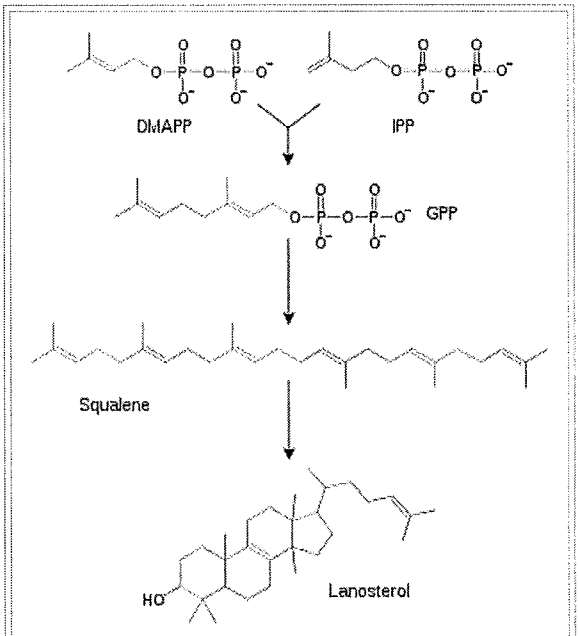
Polysaccharides and glycans are made by the sequential addition of monosaccharides by glycosyltransferase from a reactive sugar-phosphate donor such as uridine diphosphate glucose (UDP-glucose) to an acceptor hydroxyl group on the growing polysaccharide. As any of the hydroxyl groups on the ring of the substrate can be acceptors, the polysaccharides produced can have straight or branched structures.[64] The polysaccharides produced can have structural or metabolic functions themselves, or be transferred to lipids and proteins by enzymes called oligosaccharyltransferases.[65][66]

Fatty acids, isoprenoids and steroids

Further information: Fatty acid synthesis, steroid metabolism

Fatty acids are made by fatty acid synthases that polymerize and then reduce acetyl-CoA units. The acyl chains in the fatty acids are extended by a cycle of reactions that add the acyl group, reduce it to an alcohol, dehydrate it to an alkene group and then reduce it again to an alkane group. The enzymes of fatty acid biosynthesis are divided into two groups, in animals and fungi all these fatty acid synthase reactions are carried out by a single multifunctional type I protein,[67] while in plant plastids and bacteria separate type II enzymes perform each step in the pathway.[68][69]

Terpenes and isoprenoids are a large class of lipids that include the carotenoids and form the largest class of plant natural products.[70] These compounds are made by the assembly and modification of isoprene units donated from the reactive precursors isopentenyl pyrophosphate and dimethylallyl pyrophosphate.[71] These precursors can be made in different ways. In animals and archaea, the mevalonate pathway produces these compounds from acetyl-CoA,[72] while in plants and bacteria the non-mevalonate pathway uses pyruvate and glyceraldehyde 3-phosphate as substrates.[71][73] One important reaction that uses these activated isoprene donors is steroid biosynthesis. Here, the isoprene units are joined together to make squalene and then folded up and formed into a set of rings to make lanosterol.[74] Lanosterol can then be converted into other steroids such as cholesterol and ergosterol.[74][75]



Simplified version of the steroid synthesis pathway with the intermediates isopentenyl pyrophosphate (IPP), dimethylallyl pyrophosphate (DMAPP), geranyl pyrophosphate (GPP) and squalene shown. Some intermediates are omitted for clarity.

Proteins

Further information: Protein biosynthesis, amino acid synthesis

Organisms vary in their ability to synthesize the 20 common amino acids. Most bacteria and plants can synthesize all twenty, but mammals can only synthesize eleven nonessential amino acids, so nine essential amino acids must be obtained from food.[7] Some simple parasites, such as the bacteria *Mycoplasma pneumoniae*, lack all amino acid synthesis and take their amino acids directly from their hosts.[76] All amino acids are synthesized from intermediates in glycolysis, the citric acid cycle, or the pentose phosphate pathway. Nitrogen is provided by glutamate and glutamine. Amino acid synthesis depends on the formation of the appropriate alpha-keto acid, which is then transaminated to form an amino acid.[77]

Amino acids are made into proteins by being joined together in a chain by peptide bonds. Each different protein has a unique sequence of amino acid residues: this is its primary structure. Just as the letters of the alphabet can be combined to form an almost endless variety of words, amino acids can be linked in varying sequences to form a huge variety of proteins. Proteins are made from amino acids that have been activated by attachment to a transfer RNA molecule through an ester bond. This

aminoacyl-tRNA precursor is produced in an ATP-dependent reaction carried out by an aminoacyl tRNA synthetase.[78] This aminoacyl-tRNA is then a substrate for the ribosome, which joins the amino acid onto the elongating protein chain, using the sequence information in a messenger RNA.[79]

Nucleotide synthesis and salvage

Further information: Nucleotide salvage, pyrimidine biosynthesis, and purine metabolism

Nucleotides are made from amino acids, carbon dioxide and formic acid in pathways that require large amounts of metabolic energy.[80] Consequently, most organisms have efficient systems to salvage preformed nucleotides.[80][81] Purines are synthesized as nucleosides (bases attached to ribose). Both adenine and guanine are made from the precursor nucleoside inosine monophosphate, which is synthesized using atoms from the amino acids glycine, glutamine, and aspartic acid, as well as formate transferred from the coenzyme tetrahydrofolate. Pyrimidines, on the other hand, are synthesized from the base orotate, which is formed from glutamine and aspartate.[82]

Xenobiotics and redox metabolism

Further information: Xenobiotic metabolism, drug metabolism, Alcohol metabolism and antioxidants

All organisms are constantly exposed to compounds that they cannot use as foods and would be harmful if they accumulated in cells, as they have no metabolic function. These potentially damaging compounds are called xenobiotics.[83] Xenobiotics such as synthetic drugs, natural poisons and antibiotics are detoxified by a set of xenobiotic-metabolizing enzymes. In humans, these include cytochrome P450 oxidases,[84] UDP-glucuronosyltransferases,[85] and glutathione *S*-transferases.[86] This system of enzymes acts in three stages to firstly oxidize the xenobiotic (phase I) and then conjugate water-soluble groups onto the molecule (phase II). The modified water-soluble xenobiotic can then be pumped out of cells and in multicellular organisms may be further metabolized before being excreted (phase III). In ecology, these reactions are particularly important in microbial biodegradation of pollutants and the bioremediation of contaminated land and oil spills.[87] Many of these microbial reactions are shared with multicellular organisms, but due to the incredible diversity of types of microbes these organisms are able to deal with a far wider range of xenobiotics than multicellular organisms, and can degrade even persistent organic pollutants such as organochloride compounds.[88]

A related problem for aerobic organisms is oxidative stress.[89] Here, processes including oxidative phosphorylation and the formation of disulfide bonds during protein folding produce reactive oxygen species such as hydrogen peroxide.[90] These damaging oxidants are removed by antioxidant metabolites such as glutathione and enzymes such as catalases and peroxidases.[91][92]

Thermodynamics of living organisms

Further information: Biological thermodynamics

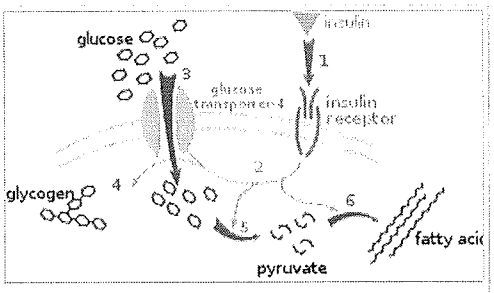
Living organisms must obey the laws of thermodynamics, which describe the transfer of heat and work. The second law of thermodynamics states that in any closed system, the amount of entropy (disorder) will tend to increase. Although living organisms' amazing complexity appears to contradict this law, life is possible as all organisms are open systems that exchange matter and energy with their surroundings. Thus living systems are not in equilibrium, but instead are dissipative systems that maintain their state of high complexity by causing a larger increase in the entropy of their environments.[93] The metabolism of a cell achieves this by coupling the spontaneous processes of catabolism to the non-spontaneous processes of anabolism. In thermodynamic terms, metabolism maintains order by creating disorder.[94]

Regulation and control

Further information: Metabolic pathway, metabolic control analysis, hormone, regulatory enzymes, and cell signaling

As the environments of most organisms are constantly changing, the reactions of metabolism must be finely regulated to maintain a constant set of conditions within cells, a condition called homeostasis.[95][96] Metabolic regulation also allows organisms to respond to signals and interact actively with their environments.[97] Two closely linked concepts are important for understanding how metabolic pathways are controlled. Firstly, the *regulation* of an enzyme in a pathway is how its activity is increased and decreased in response to signals. Secondly, the *control* exerted by this enzyme is the effect that these changes in its activity have on the overall rate of the pathway (the flux through the pathway).[98] For example, an enzyme may show large changes in activity (*i.e.* it is highly regulated) but if these changes have little effect on the flux of a metabolic pathway, then this enzyme is not involved in the control of the pathway.[99]

There are multiple levels of metabolic regulation. In intrinsic regulation, the metabolic pathway self-regulates to respond to changes in the levels of substrates or products; for example, a decrease in the amount of product can increase the flux through the pathway to compensate.[98] This type of regulation often involves allosteric regulation of the activities of multiple enzymes in the pathway.[100] Extrinsic control involves a cell in a multicellular organism changing its metabolism in response to signals from other cells. These signals are usually in the form of soluble messengers such as hormones and growth factors and are detected by specific receptors on the cell surface.[101] These signals are then transmitted inside the cell by second messenger systems that often involved the phosphorylation of proteins.[102]

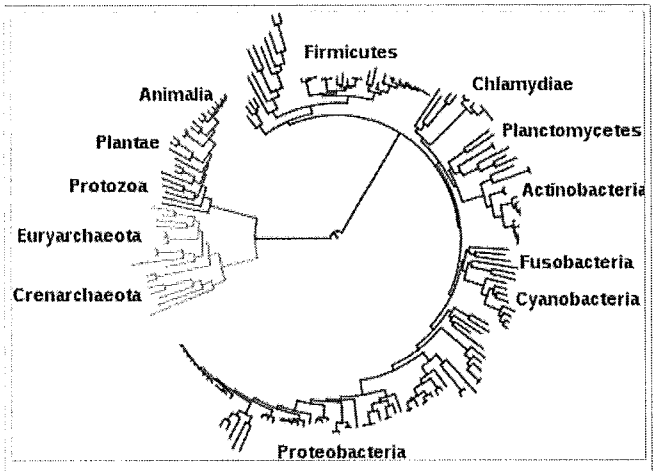


Effect of insulin on glucose uptake and metabolism. Insulin binds to its receptor (1), which in turn starts many protein activation cascades (2). These include: translocation of Glut-4 transporter to the plasma membrane and influx of glucose (3), glycogen synthesis (4), glycolysis (5) and fatty acid synthesis (6).

A very well understood example of extrinsic control is the regulation of glucose metabolism by the hormone insulin.[103] Insulin is produced in response to rises in blood glucose levels. Binding of the hormone to insulin receptors on cells then activates a cascade of protein kinases that cause the cells to take up glucose and convert it into storage molecules such as fatty acids and glycogen.[104] The metabolism of glycogen is controlled by activity of phosphorylase, the enzyme that breaks down glycogen, and glycogen synthase, the enzyme that makes it. These enzymes are regulated in a reciprocal fashion, with phosphorylation inhibiting glycogen synthase, but activating phosphorylase. Insulin causes glycogen synthesis by activating protein phosphatases and producing a decrease in the phosphorylation of these enzymes.[105]

Evolution

Further information: Molecular evolution and phylogenetics



Evolutionary tree showing the common ancestry of organisms from all three domains of life. Bacteria are colored blue, eukaryotes red, and archaea green. Relative positions of some of the phyla included are shown around the tree.

The central pathways of metabolism described above, such as glycolysis and the citric acid cycle, are present in all three domains of living things and were present in the last universal ancestor.[3][106] This universal ancestral cell was prokaryotic and probably a methanogen that had extensive amino acid, nucleotide, carbohydrate and lipid metabolism.[107][108] The retention of these ancient pathways during later evolution may be the result of these reactions being an optimal solution to their particular metabolic problems, with pathways such as glycolysis and the citric acid cycle producing their end products highly efficiently and in a minimal number of steps.[4][5] Mutation changes that affect non-coding DNA segments may merely affect the metabolic efficiency of the individual for whom the mutation occurs.[109] The first pathways of enzyme-based metabolism may have been parts of purine nucleotide metabolism, with previous metabolic pathways being part of the ancient RNA world.[110]

Many models have been proposed to describe the mechanisms by which novel metabolic pathways evolve. These include the sequential addition of novel enzymes to a short ancestral pathway, the duplication and then divergence of entire pathways as well as the recruitment of pre-existing enzymes and their assembly into a novel reaction pathway.[111] The relative importance of these mechanisms is unclear, but genomic studies have shown that enzymes in a pathway are likely to have a shared ancestry, suggesting that many pathways have evolved in a step-by-step fashion with novel functions being created from pre-existing steps in the pathway.[112] An alternative model comes from studies that trace the evolution of proteins' structures in metabolic networks, this has suggested that enzymes are pervasively recruited, borrowing enzymes to perform similar functions in different metabolic pathways (evident in the MANET database)[113] These recruitment processes result in an evolutionary enzymatic mosaic.[114] A third possibility is that some parts of metabolism might exist as "modules" that can be reused in different pathways and perform similar functions on different molecules.[115]

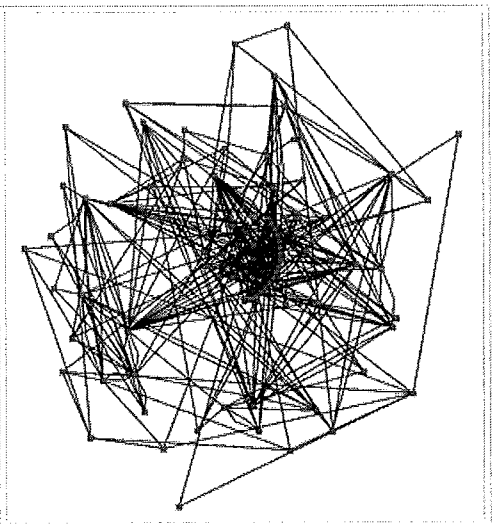
As well as the evolution of new metabolic pathways, evolution can also cause the loss of metabolic functions. For example, in some parasites metabolic processes that are not essential for survival are lost and preformed amino acids, nucleotides and carbohydrates may instead be scavenged from the host.[116] Similar reduced metabolic capabilities are seen in endosymbiotic

organisms.[117]

Investigation and manipulation

Further information: Protein methods, proteomics, metabolomics and metabolic network modelling

Classically, metabolism is studied by a reductionist approach that focuses on a single metabolic pathway. Particularly valuable is the use of radioactive tracers at the whole-organism, tissue and cellular levels, which define the paths from precursors to final products by identifying radioactively labelled intermediates and products.[118] The enzymes that catalyze these chemical reactions can then be purified and their kinetics and responses to inhibitors investigated. A parallel approach is to identify the small molecules in a cell or tissue; the complete set of these molecules is called the metabolome. Overall, these studies give a good view of the structure and function of simple metabolic pathways, but are inadequate when applied to more complex systems such as the metabolism of a complete cell.[119]



Metabolic network of the *Arabidopsis thaliana* citric acid cycle. Enzymes and metabolites are shown as red squares and the interactions between them as black lines.

An idea of the complexity of the metabolic networks in cells that contain thousands of different enzymes is given by the figure showing the interactions between just 43 proteins and 40 metabolites to the right: the sequences of genomes provide lists containing anything up to 45,000 genes.[120] However, it is now possible to use this genomic data to reconstruct complete networks of biochemical reactions and produce more holistic mathematical models that may explain and predict their behavior.[121] These models are especially powerful when used to integrate the pathway and metabolite data obtained through classical methods with data on gene expression from proteomic and DNA microarray studies.[122] Using these techniques, a model of human metabolism has now been produced, which will guide future drug discovery and biochemical research.[123] These models are now being used in network analysis, to classify human diseases into groups that share common proteins or metabolites.[124][125]

Bacterial metabolic networks are a striking example of bow-tie[126][127][128] organization, an architecture able to input a wide range of nutrients and produce a large variety of products and complex macromolecules using a relatively few intermediate common currencies.

A major technological application of this information is metabolic engineering. Here, organisms such as yeast, plants or bacteria are genetically modified to make them more useful in biotechnology and aid the production of drugs such as antibiotics or industrial chemicals such as 1,3-propanediol and shikimic acid.[129] These genetic modifications usually aim to reduce the amount of energy used to produce the product, increase yields and reduce the production of wastes.[130]

History

Further information: History of biochemistry and history of molecular biology

The term *metabolism* is derived from the Greek Μεταβολισμός – "Metabolismos" for "change", or "overthrow".[131] The history of the scientific study of metabolism spans several centuries and has moved from examining whole animals in early studies, to examining individual metabolic reactions in modern biochemistry. The first controlled experiments in human metabolism were published by Santorio Santorio in 1614 in his book *Ars de statica medicina*.[132] He described how he weighed himself before and after eating, sleep, working, sex, fasting, drinking, and excreting. He found that most of the food he took in was lost through what he called "insensible perspiration".

In these early studies, the mechanisms of these metabolic processes had not been identified and a vital force was thought to animate living tissue.[133] In the 19th century, when studying the fermentation of sugar to alcohol by yeast, Louis Pasteur concluded that fermentation was catalyzed by substances within the yeast cells he called "ferments". He wrote that "alcoholic fermentation is an act correlated with the life and organization of the yeast cells, not with the death or putrefaction of the cells."[134] This discovery, along with the publication by Friedrich Wöhler in 1828 of the chemical synthesis of urea,[135] notable for being the first organic compound prepared from wholly inorganic precursors, proved that the organic compounds and chemical reactions found in cells were no different in principle than any other part of chemistry.

It was the discovery of enzymes at the beginning of the 20th century by Eduard Buchner that separated the study of the

chemical reactions of metabolism from the biological study of cells, and marked the beginnings of biochemistry.[136] The mass of biochemical knowledge grew rapidly throughout the early 20th century. One of the most prolific of these modern biochemists was Hans Krebs who made huge contributions to the study of metabolism.[137] He discovered the urea cycle and later, working with Hans Kornberg, the citric acid cycle and the glyoxylate cycle.[138][63] Modern biochemical research has been greatly aided by the development of new techniques such as chromatography, X-ray diffraction, NMR spectroscopy, radioisotopic labelling, electron microscopy and molecular dynamics simulations. These techniques have allowed the discovery and detailed analysis of the many molecules and metabolic pathways in cells.

Santorio Santorio in his steelyard balance, from *Ars de statica medicina*, first published 1614

See also

- Anthropogenic metabolism
- Antimetabolite
- Basal metabolic rate
- Calorimetry
- Inborn error of metabolism
- Iron-sulfur world theory, a "metabolism first" theory of the origin of life.
- Primary nutritional groups
- Respirometry
- Sulfur metabolism
- Thermic effect of food
- Water metabolism

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Further reading

Introductory

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Advanced

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External links

External links

General information

- Metabolism, Cellular Respiration and Photosynthesis (http://www.biochemweb.org/metabolism.shtml) The Virtual Library of Biochemistry and Cell Biology at biochemweb.org
- The Biochemistry of Metabolism (http://www.rpi.edu/dept/bcbp/molbiochem/MBWeb/mb1/MB1index.html)
- Advanced Animal Metabolism Calculators/ Interactive Learning Tools (http://www.stthomas.edu/biol/ecophys/homepage/homepage.html)
- Microbial metabolism (http://www.slic2.wsu.edu:82/hurlbert/micro101/pages/Chap7.html) Simple overview. School level.
- Metabolic Pathways of Biochemistry (http://www.gwu.edu/~mpb/) Graphical representations of major metabolic pathways.
- Chemistry for biologists (http://www.chemsoc.org/networks/LearnNet/cfb/contents.htm) Introduction to the chemistry of metabolism. School level.
- Sparknotes SAT biochemistry (http://www.sparknotes.com/testprep/books/sat2/biology/) Overview of biochemistry. School level.
- MIT Biology Hypertextbook (http://www.sciencegateway.org/resources/biologytext/index.html) Undergraduate-level guide to molecular biology.

Human metabolism

- Topics in Medical Biochemistry (http://library.med.utah.edu/NetBiochem/titles.htm) Guide to human metabolic pathways. School level.
- http://themedicalbiochemistrypage.org/ THE Medical Biochemistry Page] Comprehensive resource on human metabolism.

Databases

- Flow Chart of Metabolic Pathways (http://www.expasy.org/cgi-bin/show_thumbnails.pl) at ExPASy
- IUBMB-Nicholson Metabolic Pathways Chart (http://www.sigmaaldrich.com/img/assets/4202/MetabolicPathways_6_17_04_.pdf)
- SuperCYP: Database for Drug-Cytochrome-Metabolism (http://bioinformatics.charite.de/supercyp/)

Metabolic pathways

- Interactive Flow Chart of the Major Metabolic Pathways (http://www2.ufp.pt/~pedros/bq/integration.htm)
- Metabolism reference Pathway (http://www.genome.ad.jp/kegg/pathway/map/map01100.html)
- Guide to Glycolysis (http://biotech.icmb.utexas.edu/glycolysis/glycohome.html) School level.
- The Nitrogen cycle and Nitrogen fixation (http://web.archive.org/*/helios.bto.ed.ac.uk/bto/microbes/nitrogen.htm) at the Wayback Machine
- Downloadable guide to photosynthesis (http://www.oxygraphics.co.uk/cds.htm) School level.
- What is Photosynthesis? (http://photoscience.la.asu.edu/photosyn/education/learn.html) Collection of photosynthesis articles and resources.

biochemical families: carbohydrates (alcohols · glycoproteins · glycosides) · lipids (eicosanoids · fatty acids / intermediates · phospholipids · sphingolipids · steroids) · nucleic acids (constituents / intermediates) · proteins (Amino acids / intermediates) · tetrapyrroles / intermediates

Anabolism

From Wikipedia, the free encyclopedia

Anabolism (from Greek *ana*, "upward", and *ballein*, "to throw") is the set of metabolic pathways that construct molecules from smaller units.[1] These reactions require energy. One way of categorizing metabolic processes, whether at the cellular, organ or organism level is as 'anabolic' or as 'catabolic', which is the opposite. Anabolism is powered by catabolism, where large molecules are broken down into smaller parts and then used up in respiration. Many anabolic processes are powered by the hydrolysis of adenosine triphosphate (ATP).[2]

Anabolic processes tend toward "building up" organs and tissues. These processes produce growth and differentiation of cells and increase in body size, a process that involves synthesis of complex molecules. Examples of anabolic processes include the growth and mineralization of bone and increases in muscle mass. Endocrinologists have traditionally classified hormones as anabolic or catabolic, depending on which part of metabolism they stimulate. The classic anabolic hormones are the anabolic steroids, which stimulate protein synthesis and muscle growth, and insulin. The balance between anabolism and catabolism is also regulated by circadian rhythms, with processes such as glucose metabolism fluctuating to match an animal's normal periods of activity throughout the day.[3]

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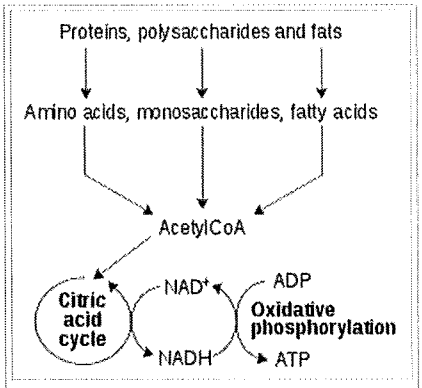
Catabolism

From Wikipedia, the free encyclopedia

For the related metabolic process, see anabolism.



Schematical diagram

Catabolism (Greek *kata* = downward + *ballein* = to throw) is the set of metabolic pathways that breaks down molecules into smaller units to release energy[1] and is related to wakefulness. In catabolism, large molecules such as polysaccharides, lipids, nucleic acids and proteins are broken down into smaller units such as monosaccharides, fatty acids, nucleotides, and amino acids, respectively. As molecules such as polysaccharides, proteins, and nucleic acids are made from long chains of these small monomer units (*mono* = one + *mer* = part), the large molecules are called polymers (*poly* = many).

Cells use the monomers released from breaking down polymers to either construct new polymer molecules, or degrade the monomers further to simple waste products, releasing energy. Cellular wastes include lactic acid, acetic acid, carbon dioxide, ammonia, and urea. The creation of these wastes is usually an oxidation process involving a release of chemical free energy, some of which is lost as heat, but the rest of which is used to drive the synthesis of adenosine triphosphate (ATP). This molecule acts as a way for the cell to transfer the energy released by catabolism to the energy-requiring reactions that make up anabolism. Catabolism therefore provides the chemical energy necessary for the maintenance and growth of cells. Examples of catabolic processes include glycolysis, the citric acid cycle, the breakdown of muscle protein in order to use amino acids as substrates for gluconeogenesis and breakdown of fat in adipose tissue to fatty acids.

There are many signals that control catabolism. Most of the known signals are hormones and the molecules involved in metabolism itself. Endocrinologists have traditionally classified many of the hormones as anabolic or catabolic, depending on which part of metabolism they stimulate. The so-called classic catabolic hormones known since the early 20th century are cortisol, glucagon, and adrenaline (and other catecholamines). In recent decades, many more hormones with at least some catabolic effects have been discovered, including cytokines, orexin (also known as hypocretin), and melatonin.[*citation needed*]

Many of these catabolic hormones express an anti-catabolic effect in muscle tissue. One study found that the administration of epinephrine (adrenaline) had an anti-proteolytic effect, and in fact suppressed catabolism rather than promoted it.[2] Another study found that catecholamines in general (i.e. noradrenaline/norepinephrine and adrenaline/epinephrine) greatly decreased the rate of muscle catabolism.[3]

See also

- Anabolism
- Autophagy
- Dehydration synthesis
- Hydrolysis
- Metabolism
- Nocturnal post absorptive catabolism

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Exhibit "D"

Typed Drawing

Word Mark	**DECA-DURABOLIN**
Goods and Services	(CANCELLED) IC 005. US 006 018 044 046 051 052. G & S: Hormone Preparation, namely, steroids
Mark Drawing Code	(1) TYPED DRAWING
Serial Number	78230623
Filing Date	March 27, 2003
Current Basis	44E
Original Filing Basis	1B;44E
Published for Opposition	November 11, 2003
Registration Number	2932737
Registration Date	March 15, 2005
Owner	(REGISTRANT) N.V. Organon CORPORATION NETHERLANDS Klooserstraat6 Oss NETHERLANDS 5349 AB
Attorney of Record	James E. Rosini, Esq.
Prior Registrations	0735928
Type of Mark	TRADEMARK
Register	PRINCIPAL
Live/Dead Indicator	DEAD
Cancellation Date	October 21, 2011

Generated on: This page was generated by TSDR on 2013-07-31 18:42:11 EDT

Mark: DECA-DURABOLIN

US Serial Number: 78230623

Application Filing Date: Mar. 27, 2003

US Registration Number: 2932737

Registration Date: Mar. 15, 2005

Register: Principal

Mark Type: Trademark

Status: Registration cancelled because registrant did not file an acceptable declaration under Section 8. To view all documents in this file, click on the Trademark Document Retrieval link at the top of this page.

Status Date: Oct. 21, 2011

Publication Date: Nov. 11, 2003

Date Cancelled: Oct. 21, 2011

Mark Information

Mark Literal Elements: DECA-DURABOLIN

Standard Character Claim: No

Mark Drawing Type: 1 - TYPESET WORD(S) /LETTER(S) /NUMBER(S)

Related Properties Information

Claimed Ownership of US Registrations: 0735928

Foreign Information

Foreign Registration Number: 19865

Foreign Registration Date: Mar. 29, 1971

Foreign Application/Registration Country: NETHERLANDS

Foreign Expiration Date: Mar. 29, 2010

Goods and Services

Note: The following symbols indicate that the registrant/owner has amended the goods/services:

- Brackets [..] indicate deleted goods/services;
- Double parenthesis ((..)) identify any goods/services not claimed in a Section 15 affidavit of
- Asterisks *..* identify additional (new) wording in the goods/services.

For: Hormone Preparation, namely, steroids

International Class(es): 005 - Primary Class

U.S Class(es): 006, 018, 044, 046, 051, 052

Class Status: SECTION 8 - CANCELLED

Basis: 44(e)

Basis Information (Case Level)

Filed Use: No	**Currently Use:** No	**Amended Use:** No
Filed ITU: Yes	**Currently ITU:** No	**Amended ITU:** No
Filed 44D: No	**Currently 44D:** No	**Amended 44D:** No
Filed 44E: Yes	**Currently 44E:** Yes	**Amended 44E:** No
Filed 66A: No	**Currently 66A:** No	
Filed No Basis: No	**Currently No Basis:** No	

Current Owner(s) Information

Owner Name: N.V. Organon

Owner Address: Klooserstraat6
Oss 5349 AB
NETHERLANDS

Legal Entity Type: CORPORATION

State or Country Where Organized: NETHERLANDS

Attorney/Correspondence Information

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Attorney Email Authorized: Yes

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Correspondent e-mail Authorized: Yes

Domestic Representative

Domestic Representative Name: James E. Rosini, Esq.

Phone: 2124257200

Fax: 2124255288

Domestic Representative e-mail: tmdocketny@kenyon.com

Domestic Representative e-mail Authorized: Yes

Prosecution History

Date	Description	Proceeding Number
Oct. 21, 2011	CANCELLED SEC. 8 (6-YR)	
Nov. 15, 2005	ATTORNEY REVOKED AND/OR APPOINTED	
Nov. 15, 2005	TEAS REVOKE/APPOINT ATTORNEY RECEIVED	
Mar. 15, 2005	REGISTERED-PRINCIPAL REGISTER	
Dec. 02, 2004	1(B) BASIS DELETED; PROCEED TO REGISTRATION	61756
Dec. 02, 2004	NOTICE OF ALLOWANCE CANCELLED	61756
Nov. 24, 2004	TEAS DELETE 1(B) BASIS RECEIVED	
Aug. 24, 2004	EXTENSION 1 GRANTED	
Aug. 03, 2004	EXTENSION 1 FILED	
Aug. 03, 2004	TEAS EXTENSION RECEIVED	
Jun. 15, 2004	TEAS RESPONSE TO OFFICE ACTION RECEIVED	
Jun. 15, 2004	TEAS CHANGE OF CORRESPONDENCE RECEIVED	
Feb. 03, 2004	NOA MAILED - SOU REQUIRED FROM APPLICANT	
Nov. 11, 2003	PUBLISHED FOR OPPOSITION	
Oct. 22, 2003	NOTICE OF PUBLICATION	
Sep. 15, 2003	APPROVED FOR PUB - PRINCIPAL REGISTER	
Sep. 11, 2003	FAX RECEIVED	
Sep. 12, 2003	EXAMINER'S AMENDMENT MAILED	
Sep. 11, 2003	ASSIGNED TO EXAMINER	76624

TM Staff and Location Information

TM Staff Information - None

File Location

Current Location: PUBLICATION AND ISSUE SECTION

Date in Location: Mar. 15, 2005

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Web interface last modified: Jul 8, 2013 v.2.3.4

Typed Drawing

Word Mark	**DECA-DURABOLIN**
Goods and Services	(CANCELLED) IC 005. US 018. G & S: Hormone Preparation. FIRST USE: 19600707. FIRST USE IN COMMERCE: 19601117
Mark Drawing Code	(1) TYPED DRAWING
Serial Number	72136387
Filing Date	January 23, 1962
Current Basis	1A
Original Filing Basis	1A
Registration Number	0735928
Registration Date	August 14, 1962
Owner	(REGISTRANT) Organon Inc. CORPORATION NEW JERSEY West Orange NEW JERSEY
Attorney of Record	James E. Rosini, Esq.
Prior Registrations	0641324
Type of Mark	TRADEMARK
Register	PRINCIPAL
Affidavit Text	SECT 15. SECT 8 (6-YR).
Renewal	1ST RENEWAL 19820814
Live/Dead Indicator	DEAD
Cancellation Date	May 17, 2003

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Mark: DECA-DURABOLIN

US Serial Number: 72136387

Application Filing Date: Jan. 23, 1962

US Registration Number: 735928

Registration Date: Aug. 14, 1962

Register: Principal

Mark Type: Trademark

Status: Registration cancelled because registrant did not file an acceptable declaration under Section 8. To view all documents in this file, click on the Trademark Document Retrieval link at the top of this page.

Status Date: May 17, 2003

Date Cancelled: May 17, 2003

Mark Information

Mark Literal Elements: DECA-DURABOLIN

Standard Character Claim: No

Mark Drawing Type: 1 - TYPESET WORD(S) /LETTER(S) /NUMBER(S)

Related Properties Information

Claimed Ownership of US Registrations: 0641324

Goods and Services

Note: The following symbols indicate that the registrant/owner has amended the goods/services:

- Brackets [..] indicate deleted goods/services;
- Double parenthesis ((..)) identify any goods/services not claimed in a Section 15 affidavit of
- Asterisks *..* identify additional (new) wording in the goods/services.

For: Hormone Preparation

International Class(es): 005

U.S Class(es): 018 - Primary Class

Class Status: SECTION 8 - CANCELLED

Basis: 1(a)

First Use: Jul. 07, 1960

Use in Commerce: Nov. 17, 1960

Basis Information (Case Level)

Filed Use: Yes	**Currently Use:** Yes	**Amended Use:** No
Filed ITU: No	**Currently ITU:** No	**Amended ITU:** No
Filed 44D: No	**Currently 44D:** No	**Amended 44D:** No
Filed 44E: No	**Currently 44E:** No	**Amended 44E:** No
Filed 66A: No	**Currently 66A:** No	
Filed No Basis: No	**Currently No Basis:** No	

Current Owner(s) Information

Owner Name: Organon Inc.

Owner Address: West Orange, NEW JERSEY
UNITED STATES

Legal Entity Type: CORPORATION

State or Country Where Organized: NEW JERSEY

Attorney/Correspondence Information

Attorney of Record

Attorney Name:	James E. Rosini, Esq.	**Docket Number:**	13514/999
Attorney Primary Email Address:	tmdocketny@kenyon.com	**Attorney Email Authorized:**	Yes

Correspondent

Correspondent Name/Address:	JAMES E ROSINI ESQ KENYON & KENYON ONE BROADWAY NEW YORK, NEW YORK 10004 UNITED STATES

Phone:	212-425-7200	**Fax:**	212-425-5288
Correspondent e-mail:	tmdocketny@kenyon.com	**Correspondent e-mail Authorized:**	Yes

Domestic Representative

Domestic Representative Name:	James E. Rosini, Esq.	**Phone:**	2124257200
Fax:	2124255288		
Domestic Representative e-mail:	tmdocketny@kenyon.com	**Domestic Representative e-mail Authorized:**	Yes

Prosecution History

Date	Description	Proceeding Number
Nov. 15, 2005	ATTORNEY REVOKED AND/OR APPOINTED	
Nov. 15, 2005	TEAS REVOKE/APPOINT ATTORNEY RECEIVED	
May 17, 2003	CANCELLED SEC. 8 (10-YR)/EXPIRED SECTION 9	
Oct. 25, 1984	REGISTERED - SEC. 8 (6-YR) ACCEPTED & SEC. 15 ACK.	
Aug. 14, 1982	REGISTERED AND RENEWED (FIRST RENEWAL - 20 YRS)	

Maintenance Filings or Post Registration Information

Affidavit of Continued Use:	Section 8 - Accepted
Affidavit of Incontestability:	Section 15 - Accepted
Renewal Date:	Aug. 14, 1982

TM Staff and Location Information

TM Staff Information - None

File Location

Current Location:	Not Found	**Date in Location:**	Not Found

No assignment has been recorded at the USPTO

For Serial Number: 72136387

If you have any comments or questions concerning the data displayed, contact PRD / Assignments at 571-272-3350. v.2.3.4
Web interface last modified: Jul 8, 2013 v.2.3.4